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Seismic Investigation Report for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant Paducah, Kentucky

CLEARED FOR PUBLIC RELEASE

APPENDIX A

TECHNICAL MEMORANDUM FOR THE PALEOLIQUEFACTION STUDY

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August 2002

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ACRONYMS

BJC	Bechtel Jacobs Company LLC
^{14}C	carbon-14
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	U.S. Department of Energy
WKWMA	West Kentucky Wildlife Management Area

Ground inspections were planned for selected areas located within a 15-mile radius of the PGDP. The Seismic Assessment Plan defines the ground inspection task as including the following:

> Prior to conducting the inspections, areas that are susceptible to liquefaction will be identified using the information gathered from the historical data review. These areas include a combination of the following characteristics: late Quaternary and Holocene sediments, areas where loose sands are present, and areas where the water table is shallow (i.e., ≤ 2 to 5 m). The 25-km radius study area will be divided into six subareas: the PGDP site, central, north, south, east, and west. The most promising targets in each subarea will be inspected. The areas to be evaluated are limited to existing exposures. Sites such as stream channels that allow a visible observation of cross-sectional evidence of liquefaction and areas that may contain other evidence of regional strong motion are preferred.

The Seismic Assessment Plan identified the following locations as potentially promising areas for inspection during the Paleoliquefaction Study:

- Ohio River bank exposures,
- Cache River cut-off (near Karnak, Illinois),
- Mayfield Creek exposures (Kentucky),
- exposures near Big Bay (Illinois),
- PGDP North-South Diversion Ditch,
- Bayou Creek and Little Bayou Creek (near the PGDP),
- Clarks River (east of Paducah, Kentucky), and
- Barnes Creek fault (Illinois).

Section 2.2 of the Seismic Assessment Plan further described expectations for the ground inspections as follows:

> It is assumed that no more than 15 locations will be visited, and up to 2000 ft of streambed will be inspected at each location. No new pits or trenches will be excavated or created for this study. Land accessibility on non-DOE-owned private and public land may limit observation of some areas. Access to some of these exposures may require the use of a boat or canoe. Limited (i.e., less than one day, total) aerial inspections of target streams or features may be conducted, if deemed necessary.

> Up to 22 organic samples (total) may be collected and sent to an approved off-site laboratory for ^{14}C age dating. The ages of these samples will be used to determine the age of the sediments under investigation and the approximate age of any observed liquefaction features.... The ^{14}C laboratory results will be entered into the Paducah Oak Ridge Environmental Information System database. The presence and/or absence of features at each inspected area will be documented in field notebooks. Liquefaction features that are discovered will be documented (including date, location, pertinent features, and other observations), photographed, and measured (depth, width, or extent). Results from this study will be summarized in the Remedial Investigation/Feasibility Study (RI/FS) report of disposal options for CERCLA-derived waste at PGDP. With the possible exception of activities conducted in the North-South Diversion Ditch, Bayou Creek, and Little Bayou Creek, all work will be conducted in uncontaminated areas and no investigation-derived waste (IDW) will be generated.

Aerial inspections were not conducted as part of this assessment. In order to conduct the ground inspections, DOE required Bechtel Jacobs Company LLC (BJC) to contact private property landowners of each parcel of property involved in the study and obtain signed access agreements.

2.2 SUMMARY OF WORK PERFORMED

The Paleoliquefaction Study was performed by SAIC Engineering, Inc., under subcontract to BJC, DOE's Management and Integration contractor.

2.2.1 Historical Data Review

Geologic Maps: Federal and Commonwealth of Kentucky regulations define a fault as active if it has had movement in the last 10,000 to 12,000 years (during the Holocene Epoch). This criterion was used to focus the investigation of paleoliquefaction features to Holocene deposits, although any fault-related features in older material would not be ignored. Thus, a first task in the review of existing data was to prepare a map of young geologic units within the study area. For the intent of this study, all units of Quaternary age (Pleistocene and Holocene age) were identified (Fig. A.1). This map reveals that the primary area of interest for the Paleoliquefaction Study lies within the floodplains of the Ohio River and its major tributaries, primarily Mayfield Creek, and within the basin of the ancestral Cache River (located in southern Illinois).

Geologic maps at a scale of 1:24,000 are available for all of Kentucky and select areas of Illinois (Fig. A.2). All of the existing 1:24,000 scale maps and regional maps at smaller scale were reviewed to identify areas of faulting and areas of sand or gravel deposits within the Quaternary units. Geologic maps reviewed as part of this study are listed on the attached reference list. The assessment revealed the following:

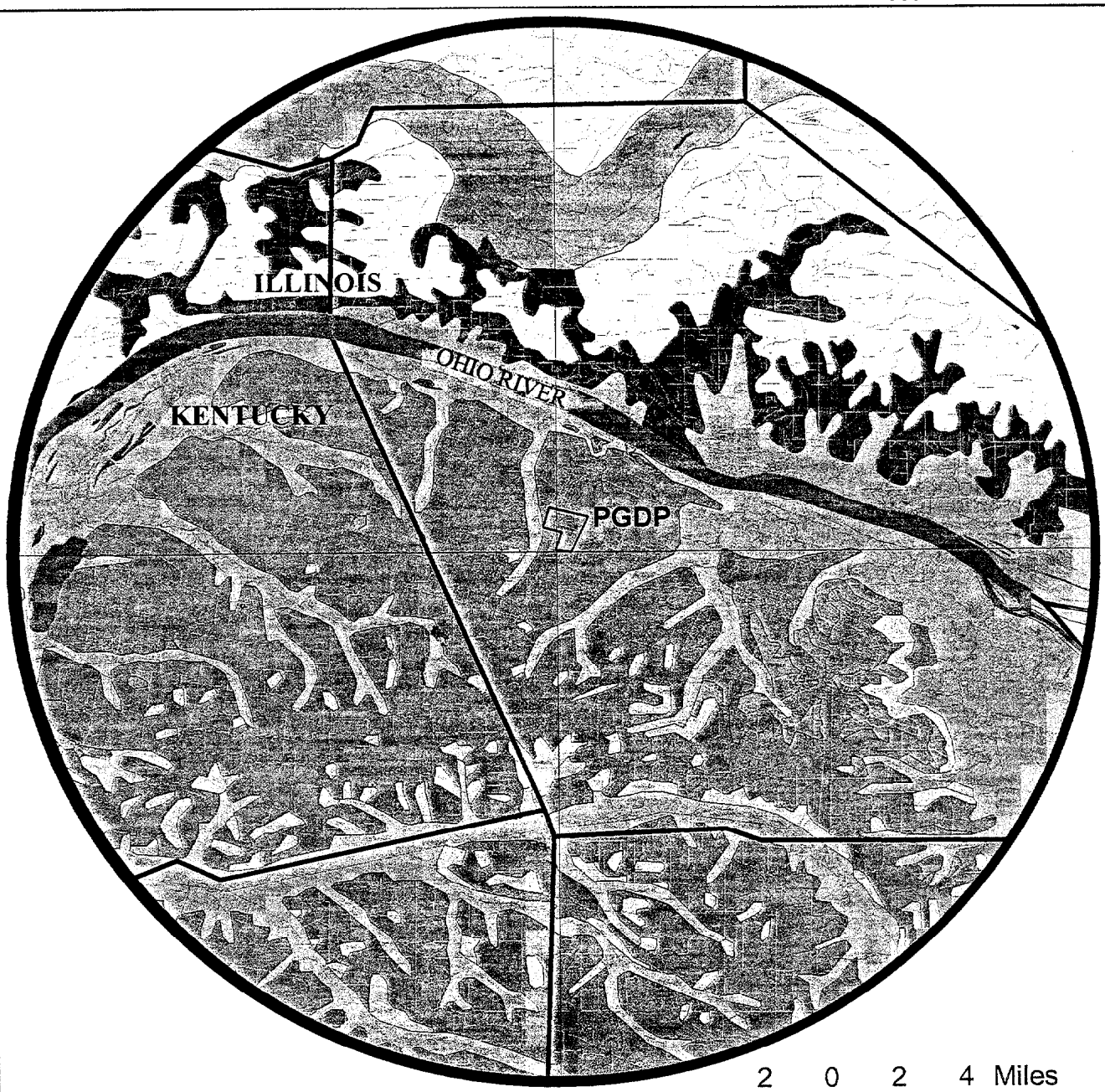
- Few mapped faults of tectonic origin occur in or near Quaternary units.
- The known Quaternary sand and gravel deposits tend to be associated with the present bank of the Ohio River and in discrete bands paralleling the Ohio River and other primary surface drainage features.

Existing Borehole Data: The PGDP plant area and the surrounding DOE property contain hundreds of soil borings that were drilled during the installation of monitoring wells and performance of environmental investigations and engineering studies. These data are documented in numerous separate reports and are compiled in informal SAIC soil boring databases. As part of the Paleoliquefaction Study, project personnel reviewed area soil boring logs for evidence of subsurface paleoliquefaction features. In particular, the soil boring logs were reviewed for records of the following:

- clastic dikes, such as those reported in the Porters Creek Clay in the PGDP area by W.W. Olive (USGS 1966),
- evidence of sand-filled vertical fractures or other vertical structures, and
- zones of anomalous sand deposits.

The majority of soil boring logs for the PGDP area represents Quaternary geologic units of the ancestral Tennessee River valley (Lower and Upper Continental Deposits) and the overlying Quaternary loess. This review established the absence of clastic dikes or similar structures in the completed soil borings. While some soil boring logs described clay-filled fractures or vertical-oriented mottling in the Quaternary loess, these descriptions were consistent with vertical fracture and fill patterns that are common in loess, independent of liquefaction features. None of the soil borings document sand deposits within the Quaternary loess. The logs for soil borings MW220 and MW221 of the C-746-S/T area, located north of the PGDP, report vertical fractures in silt and clay layers directly overlying sand of the Lower Continental Deposits. It remains uncertain whether these occurrences represent features formed at or soon after the period of deposition (known as "loading structures" and not of seismic origin) or formed after deposition in response to an earthquake. Neither of these logs describe overlying sand intervals that appeared to be buried "sand blow" deposits.

The soil boring logs rarely report anomalous sand deposits, but none with features that were uniquely of paleoliquefaction origin. This review considered descriptions of grading, stiffness, cross-cutting bedding,



AGE			ILLINOIS	KENTUCKY
Cenozoic	Quaternary	Holocene	— —	Alluvium
		Pleistocene	Equality Fm. / Cahokia/ Henry Fm.	Loess / Continental Deposits
	Tertiary	Pliocene/ Miocene?	— —	
		Eocene	— —	Jackson/Claiborne Fm. / Wilcox Group
		Paleocene	— —	Porters Creek Clay
Mesozoic			— —	
Paleozoic	Undifferentiated		Paleozoic rock	— —

LEGEND:
ROAD
SURFACE WATER

U.S. DEPARTMENT OF ENERGY
DOE OAK RIDGE OPERATIONS
PADUCAH GASEOUS DIFFUSION PLANT

BECHTEL JACOBS COMPANY, LLC
MANAGED FOR THE US DEPARTMENT OF ENERGY UNDER US GOVERNMENT CONTRACT DE-AC-05-98OR22700
Oak Ridge, Tennessee • Paducah, Kentucky • Portsmouth, Ohio

Science Applications International Corporation
P.O. Box 2502
Oak Ridge, Tennessee 37831

Fig. A.1. Kentucky/Illinois geology within 15 miles radius of Site 3A.

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DATE 06-04-01

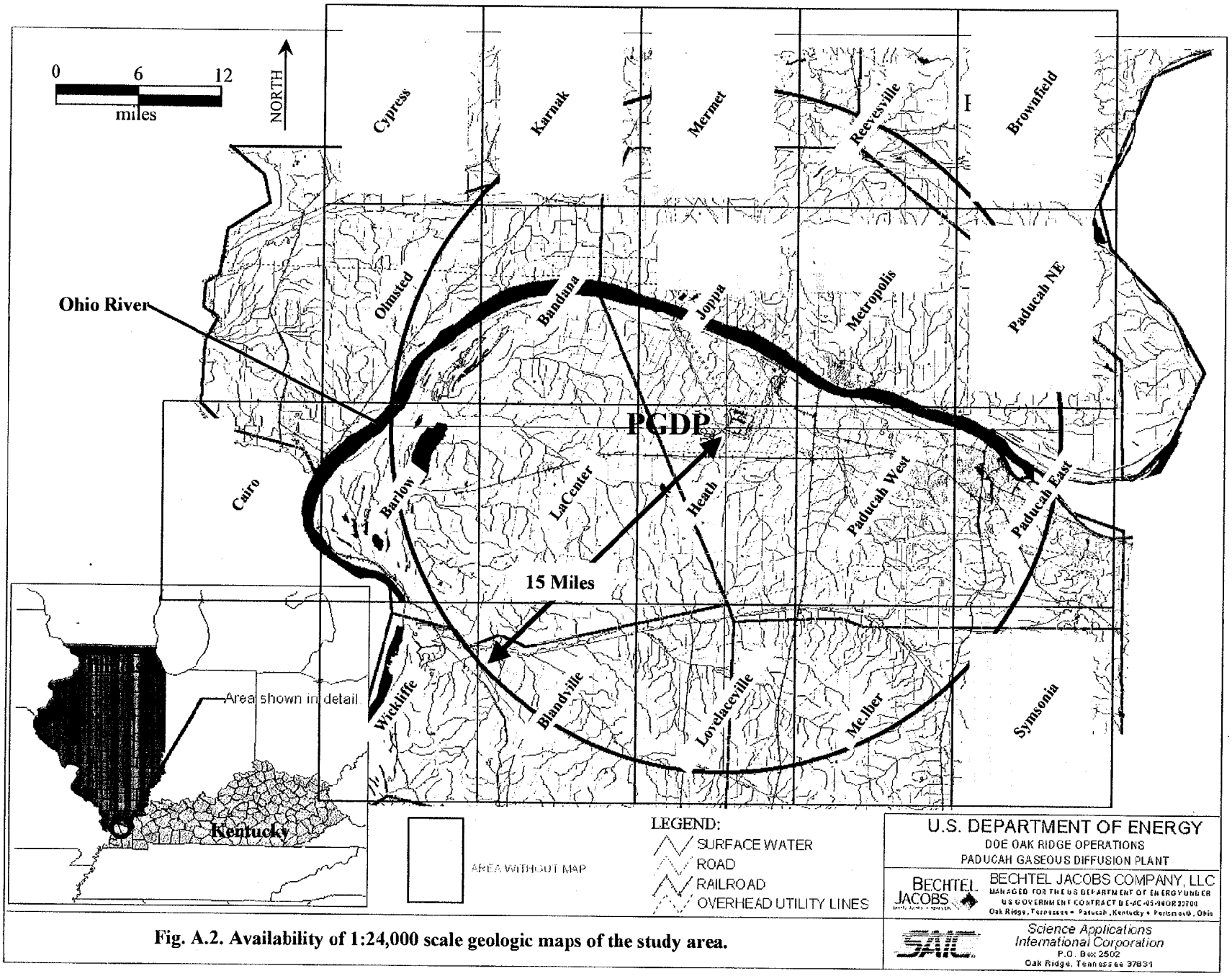


Fig. A.2. Availability of 1:24,000 scale geologic maps of the study area.

and included organic material and apparent degree of weathering in an attempt to identify paleoliquefaction features. In no case do the PGDP soil boring logs document buried soil horizons overlain by sand intervals that would be highly suggestive of a "sand blow" deposit.

Soils Series Maps: In a further attempt to locate sand or gravel deposits, county soil surveys of the U.S. Soil Conservation Service were obtained for the region of study, where available. The soils series maps, presented on an aerial photo base map, were reviewed to identify areas of sandy or gravelly soils series at the ground surface and photographic evidence of paleoliquefaction features. Soil series maps reviewed as part of this study are listed on the attached reference list.

With the exception of the current Ohio River banks, the soils series maps of the study area rarely identified sand or gravel surface soils; most of the soils are loam. The analysis of the aerial photography base maps did not distinguish any paleoliquefaction features based on photographic evidence; however, it was found that the soils series maps for Illinois counties identify discrete features called "sand spots." The origin of these sand spots may be related to paleoliquefaction and several Illinois sites with sand spots were selected for consideration as field study sites. (Note that the same features may exist in Kentucky but were not mapped by the U.S. Soil Conservation Service.) Figure A.3 shows the soil surveys in the study area that were reviewed for the Paleoliquefaction Study and the location of mapped sand spots. The review of geologic and soil maps led to the initial selection of 32 candidate sites for further review. Table A.1 summarizes this initial set of sites.

Uppermost Aquifer Maps. A map of water levels for the shallowest aquifers across western Kentucky (Plate 10 from USGS 1973) was obtained to compare with topographic maps, as a means of identifying areas where the water table is near the land surface. Similar maps are unavailable for southern Illinois. Comparison of the available maps for the PGDP area revealed that the process did not identify all areas with a shallow water table. Because most of the known sand units in the regional study area are adjacent to the Ohio River and its primary tributaries, it could be assumed that these sand deposits had been, and may continue to be, sites of a shallow water table. This is a conservative assumption that would not exclude any areas from further study.

Topographic Maps. The Paleoliquefaction Study included review of 1:24,000 scale topographic maps for the areas of initial interest primarily to assess accessibility and topographic relief or the presence of drainage features (e.g., ditches). Topographic maps reviewed as part of this study are listed on the attached reference list. Potential study sites were considered most accessible if they were located along public transportation routes (i.e., roads or rail lines) or along the banks of the Ohio River or other drainageways. The candidate study sites needed to possess topographic relief or some erosional/drainage feature to expose the site soils in cross section. Small-scale paleoliquefaction features, whether manifested as a sand blow or sand-filled fracture, are most evident in cross section where textures and structures can be viewed.

Analysis. A subsequent review of the above criteria identified a subset of 13 sites (Fig. A.4) from the 32 initial sites listed in Table A.1, distributed across the region of study, with better potential for the presence and observation of paleoliquefaction features and better accessibility, as candidates for field study. Table A.2 presents the location of these sites along with a description of key criteria for the site selection and accessibility. The 13 candidate sites include a long stretch of Mayfield Creek, although geologic and soil series maps did not identify sand or gravel deposits along Mayfield Creek. Mayfield Creek was selected for field assessment because the setting is sufficiently similar to areas located further south where paleoliquefaction features have been documented and because the creek is the only potential study site in the southern half of the region of study.

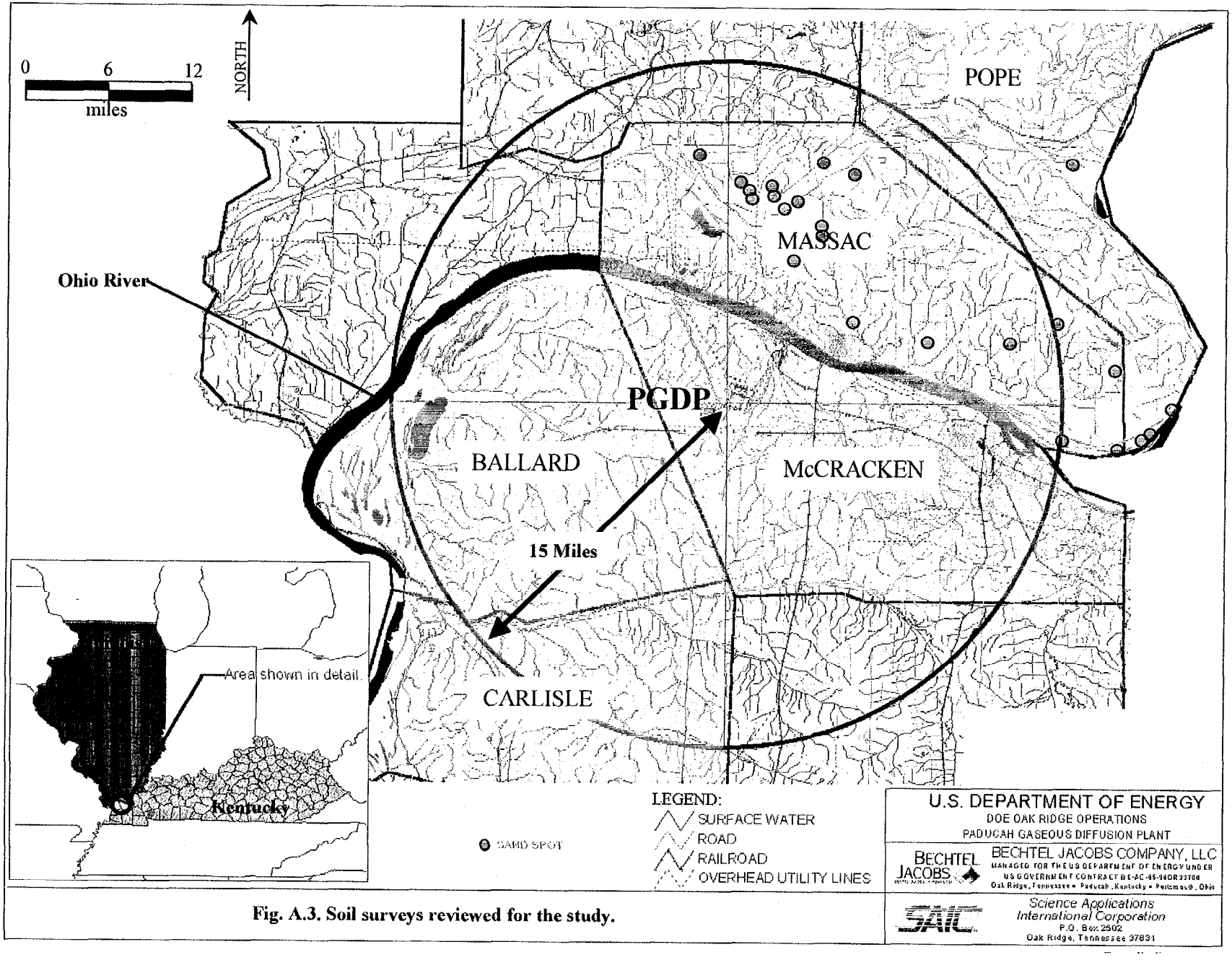


Fig. A.3. Soil surveys reviewed for the study.

Table A.1. Initial candidates for the field study sites

Site Number	Location	Description	Access	Notes
1	Joppa Quad, Little Bayou Creek on west side of Shawnee Steam Plant	• mapped Quaternary silt and sand deposit • good exposures on west bank of creek	• along PGDP water supply pipeline	• good site
2	Paducah West Quad, Ohio River bank (south) from Brookport Bridge to Dam 52 access road	• mapped large sand deposit of Quaternary alluvium • low river stage exposure	• access road to Dam 52 and access road on west side of Brookport Bridge	• good site expected
3	Heath Quad, West Fork Massac Creek at the intersection of Biggs and Childress Roads	• mapped Continental Deposits on hillside • gravel pit	• intersection of Biggs and Childress Roads	• poor site expected
4	Joppa Quad, east side of Metropolis Lake	• mapped Quaternary silt and sand deposit • gravel pit in hillside exposure	• access road likely on private property	• poor site expected • accessibility issues
5	Metropolis Quad, 1,000 to 2,000 ft west of Massac Creek at the Ohio River	• mapped Quaternary silt and sand deposit and sand deposit of Quaternary alluvium on hillside • on trend of possible fault	• off access road, likely on private property	• poor site expected • accessibility issues
6	Joppa Quad, north bank of Ohio River at Joppa boat ramp	• alluvial soil series	• Joppa boat ramp	• presence of sand deposit unknown
7	Melber Quad, north side of Blizzard Ponds Drainage Canal on east side of KY Hwy 1014	• gravel pits in hillside • Brandon silty clay loam	• access off power line R/W, likely on private property	• poor site expected • accessibility issues
8	Melber Quad, north bank of Mayfield Creek	• road cuts of Cross Mill Road, KY Hwy 786 and 1241, and US Hwy 45 • hillside Flomaton series soils	• road & highway R/W	• presence of sand deposit unknown
9	Metropolis Quad, north bank of Ohio River at Fort Massac boat ramp	• mapped Cont. deposits • mapped suspect fault in rip rap covered area • low river stage exposure	• Illinois park	• limited vertical exposure expected
10	Metropolis Quad, banks of Barnes Creek east of IL Hwy 145	• creek bank exposure of Quaternary deposits overlying faults in Cretaceous McNairy Formation	• USGS access to private property	• good site • limited vertical exposure of Quaternary deposits
11	Metropolis Quad, southeast of Round Knob	• sand spots and borrow pit in Saffell series soils	• secondary road marked "No Trespassing"	• poor site expected • accessibility issues
12	Paducah East Quad, east and west banks of Island Creek	• creek bank Quaternary lacustrine and fluvial deposits • mapped as alluvial series soils	• Kolb Park on west bank • secondary access road adjacent to west bank	• presence of sand deposit unknown • access difficult
13	Paducah East Quad, west bank of Clarks River	• Quaternary lacustrine and fluvial deposits • mapped as alluvial series soils	• limited access	• presence of sand deposit unknown • access difficult
14	Paducah East Quad, east bank of Clarks River in Reidland	• mapped hillside Continental Deposits (Quaternary) above clastic dike in Porters Creek Clay (Paleocene)	• access from back side of high school	• poor site expected • accessibility issues

Table A.1. Initial candidates for the field study sites (continued)

Site Number	Location	Description	Access	Notes
15	Paducah East Quad, hillside west of I-24 Interchange 11 and east of KY Hwy 994, overlooking Island and Champion Creeks	• mapped landslide block faults within and at base of Continental Deposits (Quaternary) • gravel pit in Continental Deposits • Cont. deposits overlie Wilcox Formation (Eocene)	• limited access • likely private property	• poor site expected • accessibility issues
16	Paducah West Quad, north hillside of intermittent tributary to Massac Creek, west of KY Hwy 970	• mapped Cont. deposits (Quaternary) and Wilcox Formation (Eocene) • fault mapped in Wilcox and inferred through Cont. deposits	• limited access • likely private property	• poor site expected • accessibility issues
17	Paducah West Quad, east hillside of Massac Creek, north and south of KY Hwy 305	• mapped Quaternary silt and sand deposits and Cont. deposits (Quaternary) • gravel pits in Cont. deposits	• limited access to south along power line R/W • access restricted to north, possibly accessible along Paducah and Illinois RR R/W	• limited vertical exposure expected • accessibility issues
18	Wickliffe Quad, east hillside overlooking Mississippi River	• Brandon and Saffell soil series from bluffs	• access to north very limited • access to south through site of Fort Jefferson	• presence of sand deposit unknown • access difficult
19	Wickliffe Quad, south bank of Cane Creek east of US Hwy 60	• Brandon series soils on hillside	• access very limited	• poor site expected • presence of sand deposit unknown • accessibility issues
20	Brownsfield Quad, east bank of Bay Creek south of Homberg, IL	• sand spots on soil map delineate sand body in Cache River deposits near Bay Creek	• access very limited	• poor site expected • presence of sand deposit unknown • accessibility issues, access difficult
21	Paducah East Quad, north bank of Ohio River south of Unionville, IL	• numerous sand spots on soil map • 4-mile reach of Ohio River bank • low river stage exposure	• Ohio River access roads	• good site expected • limited vertical exposure of Quaternary deposits
22	Paducah East Quad, Norton's Bluff, south bank of Tennessee River, east of Clarks River	• mapped fault in Cont. deposits (Quaternary) and McNairy Formation (Cretaceous) • 1 mile of river bank exposure	• access roads, status unknown	• good exposure expected • presence of sand deposits unknown
23	Paducah East Quad, Livingston Point, banks of Ohio and Tennessee Rivers	• mapped as sitly sand on engineering geology map • low river stage exposure	• access roads, status unknown	• good exposure expected • accessibility issues
24	Paducah West Quad, south of KY Hwy 305 at old railroad grade	• mapped as Quaternary sand deposit • low relief, possibly exposed along old railroad grade	• old railroad grade accessed from Stewart Nelson Park	• poor exposure expected • accessibility issues

Table A.1. Initial candidates for the field study sites (continued)

Site Number	Location	Description	Access	Notes
25	Bandana Quad, Oscar Bottoms	• mapped sand deposit in Quaternary alluvium (1-mile reach) • Wheeling silt loam soil series (WhC) with gravel pit	• secondary river access roads • status unknown • secondary access road crosses WhC, • limited access • likely private property	• low river stage exposure • very poor exposure expected • presence of sand deposit unknown • accessibility issues
26	Joppa Quad, south Ohio River bank, river miles 950 to 951	• promontory/island in Ohio River • mapped as Alluvial soil series • large exposed sand bar on McCracken Co. soil map - Plate 4	• presence of sand unknown • status of access road unknown • likely on private property	• low river stage exposure • presence of sand deposit unknown • accessibility issues
27	Olmsted Quad, southeast Ohio River bank, northwest of Oscar	• mapped as sand deposit in Quaternary alluvium	• river access road • status of access road unknown	• low river stage exposure • accessibility issues
28	Cairo Quad, east Ohio River bank, Cache Island, west of Barlow	• mapped as sand deposit in Quaternary alluvium	• river access road • status of access road unknown	• low to average river stage exposure • accessibility issues
29	Pope County, Soil Survey Plate 84, north central area of plate	• area of four mapped sand spots in field • area of previously mapped paleolithification features	• field and forest sites • access unknown	• poor exposure • accessibility issues
30	Massac County, Soil Survey Plate 81, north central area of plate	• area of four mapped sand spots adjacent to field road	• field road • private property access unknown	• likely poor exposure • accessibility issues • part of larger area of frequent sand "spots"
31	Pulaski County, Post Creek Cutoff	• area of mapped paleolithification features	• stream bank	• stream bank exposure • accessibility unknown
32	Mayfield Creek, Ballard/Carlisle County Line	• dredged creek, floodplain	• only practical access by boat. • crossings of US Hwy 51/62 and KY Hwy 121 and 1367	• limited exposures expected • access by boat

PGDP = Paducah Gaseous Diffusion Plant
R/W – right of way
USGS = U.S. Geological Survey

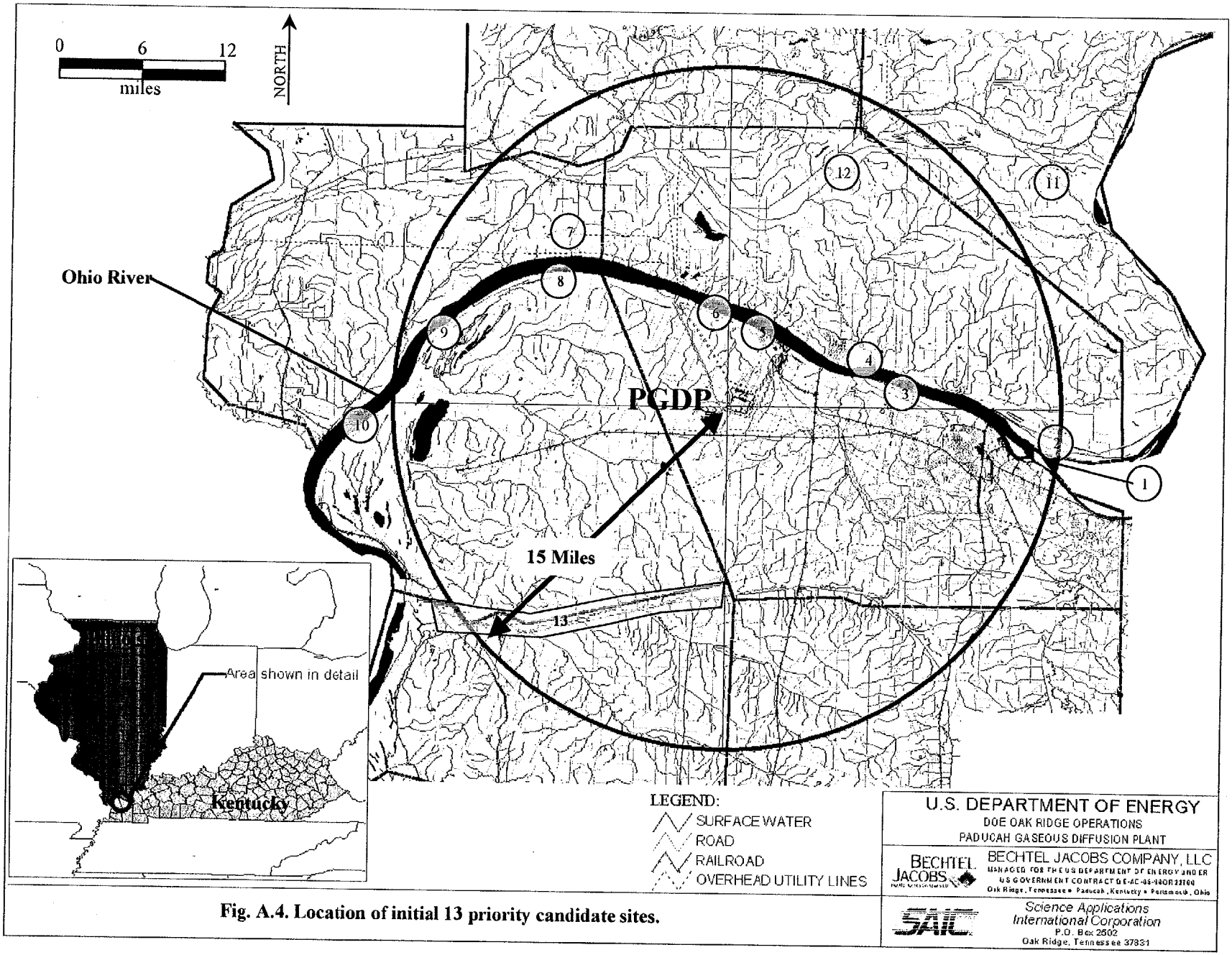


Fig. A.4. Location of initial 13 priority candidate sites.

Table A.2. Initial 13 priority candidates for the field study sites

Site Number	Location	Description	Access	Notes
1	Paducah East Quad., Livingston Point, banks of Ohio and Tennessee Rivers	• mapped as silty sand on engineering geology map • low river stage exposure	• access roads, status unknown	• good exposure expected • accessibility issues
2	Paducah East Quad., north bank of Ohio River south of Unionville, IL	• numerous sand spots on soil map • 4-mile reach of Ohio River bank • low river stage exposure	• Ohio River access roads	• good site expected • limited vertical exposure of Quaternary deposits
3	Paducah West Quad., Ohio River bank (south) from Brookport Bridge to Dam 52 access road	• mapped large sand deposit of Quaternary alluvium • low river stage exposure	• access road to Dam 52 and access road on west side of Brookport Bridge	• good site expected
4	Metropolis Quad, north bank of Ohio River at Fort Massac boat ramp	• mapped Cont. deposits • mapped suspect fault in rip rap covered area • low river stage exposure	• Illinois park	• limited vertical exposure expected
5	Joppa Quad., Little Bayou Creek on west side of Shawnee Steam Plant	• mapped Quaternary silt and sand deposit • good exposures on west bank of creek	• along PGDP water supply pipeline	• good site
6	Joppa Quad., south Ohio River bank, river miles 950 to 951	• promontory/island in Ohio River • mapped as Alluvial soil series • large exposed sand bank on McCracken Co. soil map - Plate 4	• presence of sand unknown • status of access road unknown • likely on private property	• low river stage exposure • presence of sand deposit unknown • accessibility issues
7	Pulaski County, Post Creek Cutoff	• area of mapped paleolithification features	• stream bank	• stream bank exposure • accessibility unknown
8	Bandana Quad., Oscar Bottoms	• mapped sand deposit in Quaternary alluvium (1-mile reach) • Wheeling silt loam soil series (WhC) with gravel pit	• -secondary river access roads • status unknown • secondary access road crosses WhC, • limited access • likely private property	• low river stage exposure • very poor exposure expected • presence of sand deposit unknown • accessibility issues
9	Olmsted Quad., southeast Ohio River bank, northwest of Oscar	• mapped as sand deposit in Quaternary alluvium	• river access road • status of access road unknown	• low river stage exposure • accessibility issues
10	Cairo Quad., east Ohio River bank, Cache Island, west of Barlow	• mapped as sand deposit in Quaternary alluvium	• river access road • status of access road unknown	• low to average river stage exposure • accessibility issues
11	Pope County, Soil Survey Plate 84, north central area of plate	• area of four mapped sand spots in field • area of previously mapped paleolithification features	• field and forest sites • access unknown	• poor exposure • accessibility issues
12	Massac County, Soil Survey Plate 81, north central area of plate	• area of four mapped sand spots adjacent to field road	• field road • private property access unknown	• likely poor exposure • accessibility issues • part of larger area of frequent sand "spots"
13	Mayfield Creek, Ballard/Carlisle County Line	• dredged creek, floodplain	• only practical access by boat • crossings of US Hwy 51/62 and KY Hwy 121 and 1367	• limited exposures expected • access by boat

PGDP – Paducah Gaseous Diffusion Plant

Bayou and Little Bayou Creeks border the PGDP plant area on the west and east sides, respectively. Although most of the reaches of these creeks do not lie in known favorable geologic settings for the formation of paleoliquefaction features, the creek banks offer the best exposure of shallow soils on the DOE property. The Paleoliquefaction Study included a walking survey of the banks of both creeks to search for paleoliquefaction features in the immediate vicinity of Site 3A and PGDP, in addition to the detailed investigations of the field study sites.

2.2.2 Property Access

Before fieldwork could begin at the candidate study sites, property owners were contacted to secure access agreements. Project personnel reviewed property records in the respective county courthouses to identify property owners to be contacted. This review of county records revealed that 214 properties made up the 13 study sites (Fig. A.4) and the stretches of Bayou and Little Bayou Creek that were to be included in the Paleoliquefaction Study. As a result, BJC pursued Right-of-Entry from the property owners for the Paleoliquefaction Study.

BJC's task of pursuing Right-of-Entry was contemporaneous with an Ohio River bank survey and Mayfield Creek bridge survey of the Paleoliquefaction Study. These surveys revealed that Mayfield Creek and six other Ohio River locations were unsuitable for the Paleoliquefaction Study because of poor exposure of soils. However, the Ohio River bank survey identified 9 new sites for inclusion in the Paleoliquefaction Study, for a revised total of 15 field study sites. These 15 sites appeared to offer the best combination of geologic setting for the formation of paleoliquefaction features and vertical exposure of soils in the 15-mile radius of the PGDP. Figure A.5 shows the location of the final 15 candidate sites selected for detailed field study. County courthouse records were researched to identify the affected property owners at these 15 sites. At the conclusion of these initial surveys, 50 properties were identified for acquisition of Right-of-Entry.

The 15 candidate Paleoliquefaction Study sites are located on properties of private citizens, corporations, and state and federal government. All requests for Right-of-Entry were granted for government-owned land. Private landowners and corporations generally were receptive to the DOE request for Right-of-Entry. Of the 15 candidate sites, property access was granted for all or part of 10 sites such that the goals of the site-specific study could be accomplished. Access agreements to another two sites were pending. These sites provided a good distribution of more detailed studies to assess the presence of paleoliquefaction features in the region of interest.

2.3 GROUND INSPECTIONS

2.3.1 Ohio River Bank Survey

Project personnel conducted a boat survey of the banks of the Ohio River across the entire width of the region of study and beyond (Fig. A.6). The Ohio River, via boat, provided relatively easy access to exposures of the region's sand and gravel deposits to further assess the candidate field study sites and other areas of interest. Because no Right-of-Entry had been granted at the time of the boat survey, project personnel were limited to documenting existing conditions of the bank exposures and, therefore, could not collect any samples for ^{14}C age-dating. The riverbank survey covered 50 miles of the Ohio River (100 miles of riverbank) over a 4-day survey period.

Notes on 55 discrete sites, 45 digital photographs, and 3.5 hours of video record documenting the riverbank survey are provided in Attachment A-I. Attachment A-II provides a summary of the subjects of

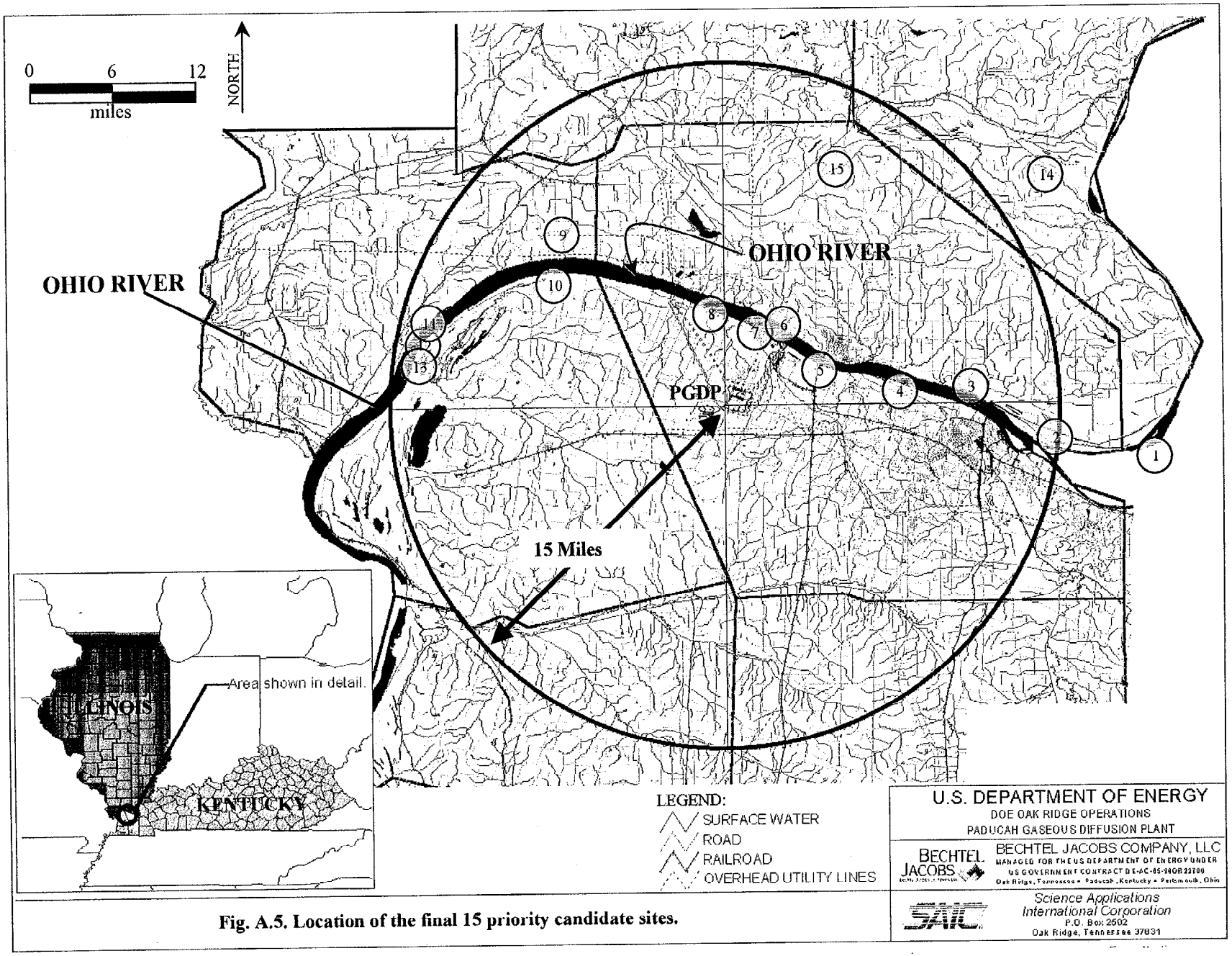


Fig. A.5. Location of the final 15 priority candidate sites.

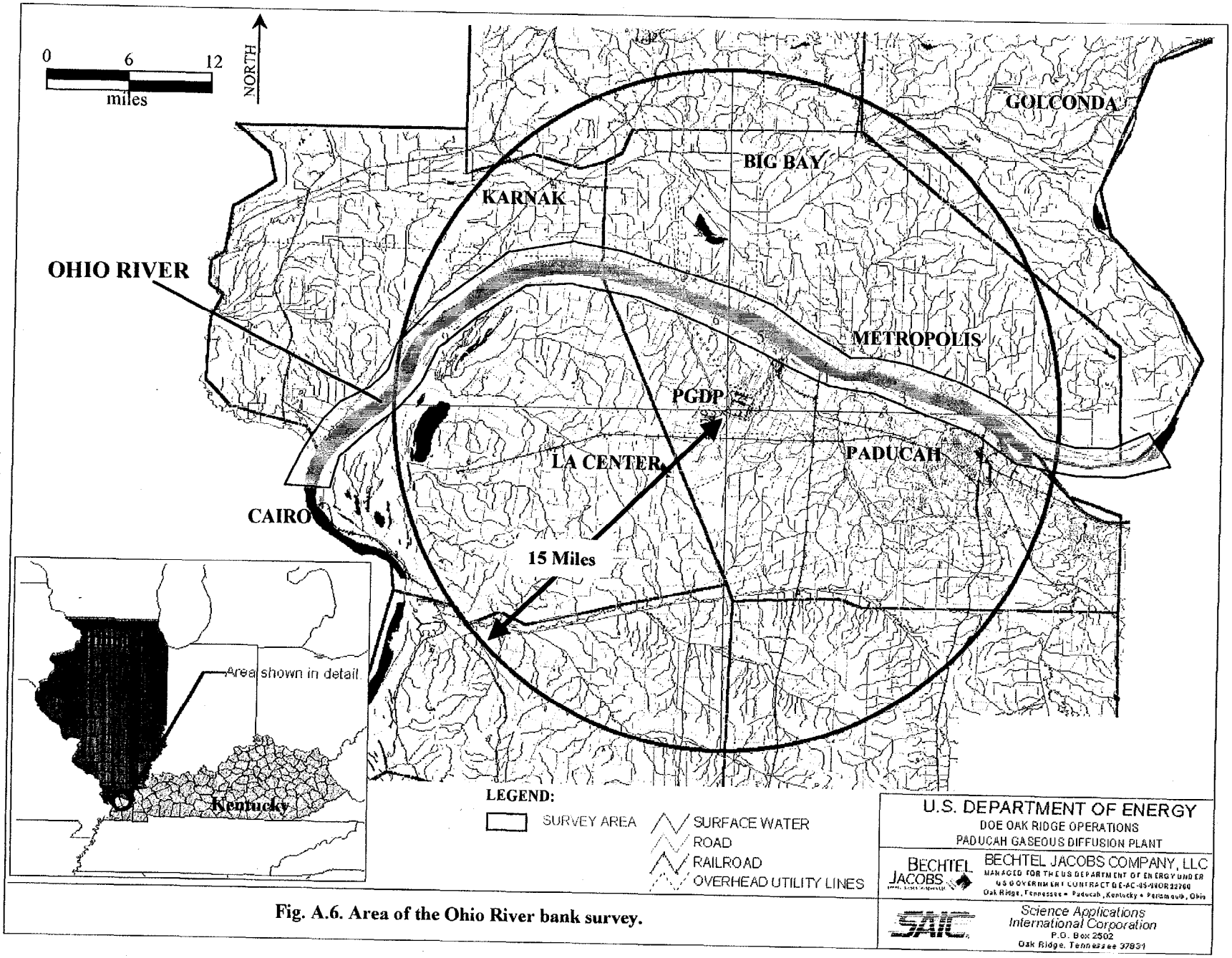


Fig. A.6. Area of the Ohio River bank survey.

the digital photos and video record. Project personnel were able to conclude the following based on the Ohio River bank survey.

- The riverbank afforded adequate exposure of the sediments such that large paleoliquefaction features, if they existed, should have been obvious.

- In general, the riverbank deposits tend to be silt and clay units containing few sand lenses capable of producing paleoliquefaction features.

- A large proportion of the Ohio River bank deposits appears to be of too recent origin (evidenced by syndepositional plastic and other anthropogenic artifacts) to contain paleoliquefaction features.

The Ohio River bank survey (Fig. A.6 and Attachment A-I) provided a valuable, region-wide search for paleoliquefaction features. The results of this survey are in agreement with a previous U.S. Geological Survey report (USGS 1989) that maps the western extent of the PGDP regional study area as "impossible to extremely difficult" as the level of relative difficulty for identifying 1811–1812 earthquake-induced liquefaction features.

2.3.2 Mayfield Creek Bridge Survey

Mayfield Creek is an improved (dredged) drainage feature that crosses through the southern half of the regional study area, near the boundaries of McCracken and Graves Counties and Ballard and Carlisle Counties, from east to west. Although no sand or gravel deposits are mapped for the Mayfield Creek basin, the creek banks appeared to offer the only significant cross section view of Quaternary sediments in the area. The creek setting is similar to Ohio River tributaries located to the south that contain known paleoliquefaction features.

In an initial attempt to assess the banks of Mayfield Creek, a windshield survey of the creek was conducted from every public road crossing of the creek (and one crossing of a tributary) within the study area (Fig. A.7 and Attachment A-III). The bridge access points consistently revealed that the creek banks are heavily vegetated, offering poor observation of the creek bank sediments. In general, the sediments tended to be silt and clay deposits with few sand lenses. In only one case was a potential paleoliquefaction feature observed. It was apparent that thick vegetation and water hazards (fast current and tree debris) would prevent closer inspection of this site.

Based on the observations of the Ohio River bank survey and the Mayfield Creek bridge survey, the candidate sites for detailed field study were revised. Figure A.5 shows the final 15 locations of the paleoliquefaction field study sites. Table A.3 summarizes the attributes of the final 15 candidate study sites.

2.3.3 Bayou and Little Bayou Creek Walkdown

Bayou and Little Bayou Creeks are Ohio River tributaries that border the industrial area of the PGDP on the west and east sides, respectively (Fig. A.8). Bayou Creek begins south of PGDP and flows across the north-to-south width of the West Kentucky Wildlife Management Area (WKWMA). Little Bayou Creek begins south of the PGDP, within the WKWMA, and transects the majority of the north-to-south width of the WKWMA. A clastic dike mapped in the bed of Bayou Creek near the southwest corner of the PGDP industrial area (USGS 1966) is of potential interest. This clastic dike crosscuts the Paleocene Porters Creek Clay; thus, the clastic dike likely predates the period of interest to the Seismic Investigation.

Geologic maps for the area of Bayou and Little Bayou Creeks identify few Quaternary sand and gravel units to target for a search for paleoliquefaction features. Nevertheless, the banks of Bayou and

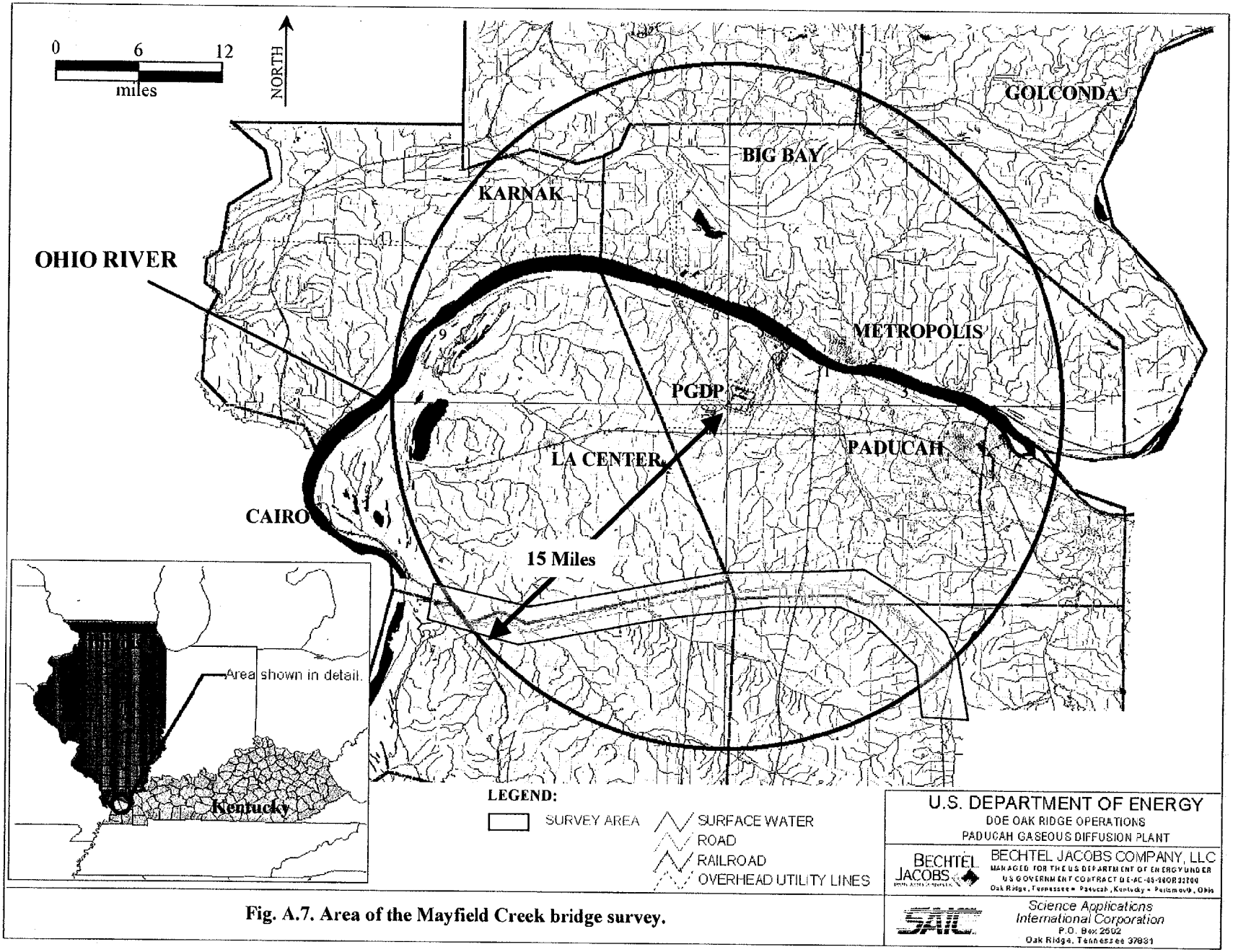
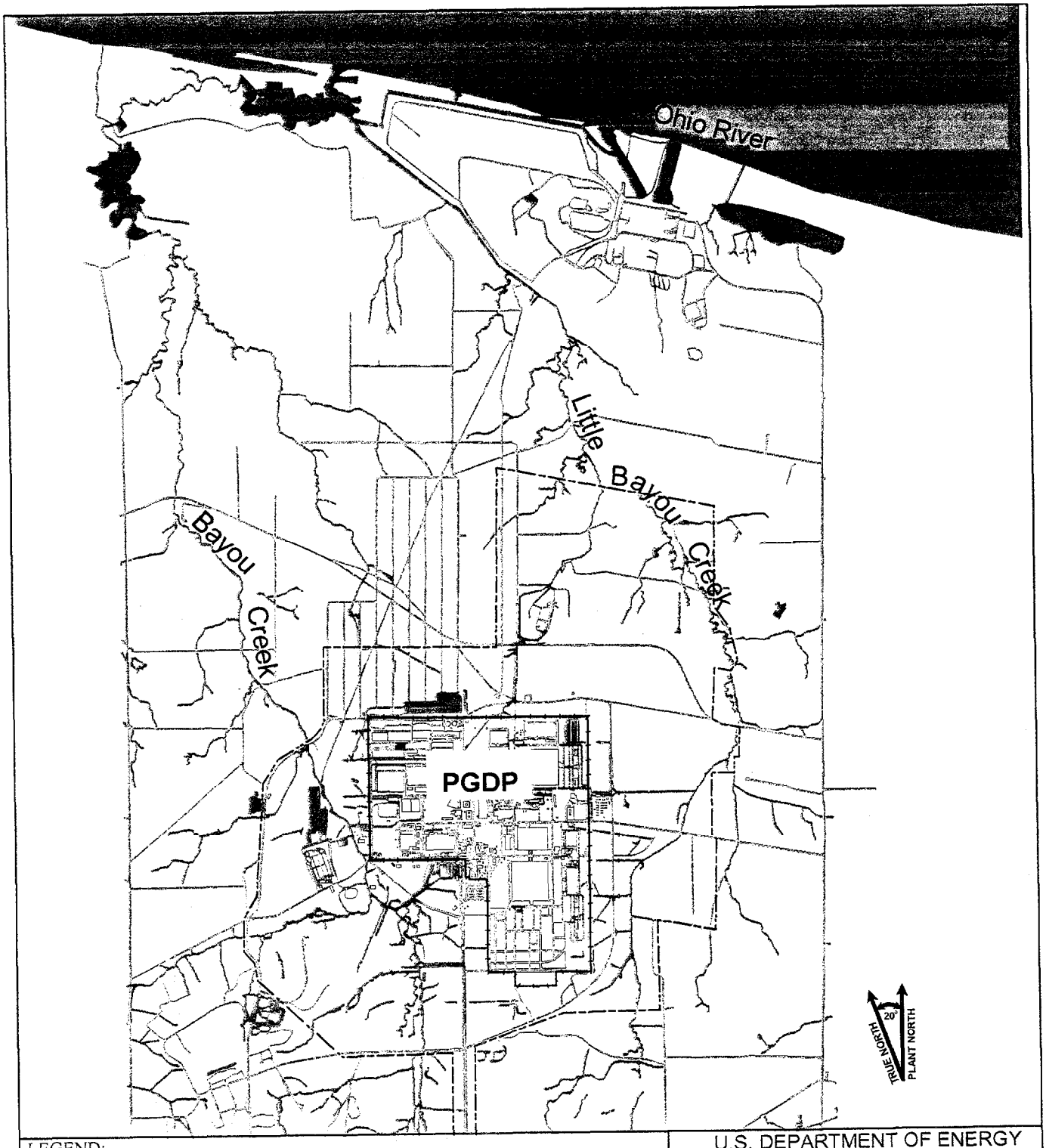


Fig. A.7. Area of the Mayfield Creek bridge survey.



LEGEND:
Road
Stream
PGDP Boundary
DOE Property Boundary
4000 0 4000 Feet

U.S. DEPARTMENT OF ENERGY
DOE OAK RIDGE OPERATIONS
PADUCAH GASEOUS DIFFUSION PLANT

BECHTEL JACOBS COMPANY LLC
MANAGED FOR THE US DEPARTMENT OF ENERGY UNDER US GOVERNMENT CONTRACT DE-AC-05-98OR22700
Oak Ridge, Tennessee • Paducah, Kentucky • Portsmouth, Ohio

Science Applications International Corporation
P.O. Box 2502
Oak Ridge, Tennessee 37831

Fig. A.8. Location of Bayou and Little Bayou Creeks.

FIGURE No. C5AC90001SK536b1.apr
DATE 07-10-02

Table A.3. Final 15 priority candidate sites for further field study

Site Number	Location	Description	Access	Notes
1	Little Cypress Quad, south bank of Ohio River, northeast of Ledbetter, KY	• 25-30 ft high, near vertical exposure • 0.5-mile reach of Ohio River bank • clay overlain by well-bedded, laminar sand	• via boat on Ohio River	• excellent site to view stratigraphy and collect samples to ^{14}C age-date the sediments
2	Paducah East Quad., north bank of Ohio River south of Unionville, IL	• numerous sand spots on soil map • 4-mile reach of Ohio River bank • low river stage exposure	• Ohio River access roads	• good site expected • limited vertical exposure of Quaternary deposits
3	Paducah East Quad., Ohio River bank (north) east of Brookport, IL	• approximately 10-ft high exposure	• -via boat on Ohio River	• good exposure of Ohio River bank sediments
4	Paducah West Quad., Ohio River bank (south) from Brookport Bridge to Dam 52 access road	• mapped large sand deposit of Quaternary alluvium • low river stage exposure	• access road to Dam 52 and access road on west side of Brookport Bridge	• good site expected
5	Metropolis Quad., banks of small tributary to Ohio River at Illinois Central Rail Road trestle	• 15 ft high exposure in east bank of tributary	• via boat on Ohio River	• good exposure of creek bank sediments
6	Joppa Quad, Ohio River bank (north) across river from TVA's Shawnee Steam Plant	• 4 ft high exposure on Ohio River bank • several 50 ft length exposures	• via boat on Ohio River	• low river stage exposure
7	Joppa Quad., Little Bayou Creek on west side of Shawnee Steam Plant	• mapped Quaternary silt and sand deposit • good exposures on west bank of creek	• along PGDP water supply pipeline	• good site
8	Joppa Quad., south Ohio River bank, river miles 950 to 951	• promontory/island in Ohio River • mapped as Alluvial soil series • large exposed sand bank on McCracken Co. soil map–Plate 4	• presence of sand unknown • status of access road unknown • likely on private property	• low river stage exposure • presence of sand deposit unknown • accessibility issues
9	Pulaski County, Post Creek Cutoff	• area of mapped paleolithification features	• stream bank	• stream bank exposure • accessibility unknown
10	Bandana Quad., Oscar Bottoms	• mapped sand deposit in Quaternary alluvium (1-mile reach) • Wheeling silt loam soil series (WhC) with gravel pit	• secondary river access roads • status unknown • secondary access road crosses WhC, • limited access • likely private property	• low river stage exposure • very poor exposure expected • presence of sand deposit unknown • accessibility issues
11	Olmsted Quad., west bank of Ohio River, north of Olmsted	• 5 ft high exposure of creek bank sediments at confluence with Ohio River	• via boat on Ohio River	• good site to observe stratigraphy • syndepositional logs
12	Olmsted Quad., east bank of Ohio River, across river from Olmsted, IL	• Ohio River bank exposure	• via boat on Ohio River	• good exposure of Ohio River sediments • potential sand blow deposit • humic-rich layer suitable for sampling for ^{14}C age-dating sediments

Table A.3. Final 15 priority candidate sites for further field study (continued)

Site Number	Location	Description	Access	Notes
13	Olmsted Quad., Humphrey Creek at Ohio River (east bank of Ohio River)	• 15 ft high exposure of sediments in south bank of Humphrey Creek at confluence with Ohio River	• via boat on Ohio River	• excellent site to observe stratigraphy
14	Pope County, Soil Survey Plate 84, north central area of plate	• area of four mapped sand spots in field • area of previously mapped paleolithification features	• field and forest sites • access unknown	• poor exposure • accessibility issues
15	Massac County, Soil Survey Plate 81, north central area of plate	• area of four mapped sand spots adjacent to field road	• field road • private property access unknown	• likely poor exposure • accessibility issues • part of larger area of frequent sand "spots"

PGDP = Paducah Gaseous Diffusion Plant
TVA = Tennessee Valley Authority

Little Bayou Creeks potentially offer the most extensive outcrop of shallow geologic units in the immediate vicinity of the PGDP. Therefore, a walkdown survey of both creeks was included as an integral component of the Paleoliquefaction Study. The first phase of the walkdown was completed: a survey of the creek banks within DOE property. A later phase of the walkdown was not performed: a survey of the creek banks outside of DOE property, contingent upon property access agreements.

Bayou Creek. The first phase creek walkdown began with Bayou Creek south of PGDP, proceeding downstream (south to north). Overall, the creek afforded frequent exposure of the creek bank sediments. Exposures typically ranged between 10 to 100 ft in length and 3 to 8 ft in height. Over the 8,000 ft of creek survey on Bayou Creek, the average distance between documented exposures was approximately 250 ft. Attachment A-IV is a summary of the documentation of creek bank exposures observed on Bayou and Little Bayou Creeks.

Most exposures of the creek bank sediments, along the entire reach of Bayou Creek that is located on DOE property, consisted of iron-cemented gravel. These gravel deposits on the southern half of the creek survey belong to the Pliocene/Pleistocene "Terrace Gravel," an older unit of the Continental Deposits, as defined by geological reports of PGDP. Similar gravel exposures found in the northern half of this survey likely belong to the Pleistocene Upper Continental Deposits unit. Clay or silt underlies the gravel unit(s) to the north. The creek bed was generally covered by loose gravel to the south.

Where overlying units are uncovered, a massive silt typically covers the gravel. This silt is thought to be a loess deposit of Pleistocene age. Occasional exposures of apparent Holocene creek deposits occur along the creek. There were very few locations where organic material was observed within the sediments that could be sampled to ^{14}C age-date the units.

The walkdown of Bayou Creek on DOE property did not reveal any obvious paleoliquefaction features; however, a suspect fault zone (which may be a creek bank slump feature) was noted in the west creek bank near the southwest corner of the PGDP industrial area. In this structure, faults appear to extend upward through the Porters Creek Clay and into the overlying cemented gravel unit (Continental Deposits, sub-unit undetermined).

Little Bayou Creek. The first phase walkdown of Little Bayou Creek proceeded in a general downstream direction over two reaches, as permitted by access points (south to north). The south reach of Little Bayou Creek (approximately 9,000 ft long is heavily vegetated with very few exposures of creek bank sediments. Exposures of creek bank sediments are comparatively frequent along the north reach of Little Bayou Creek (approximately 7,000 ft long, averaging a documented exposure every 450 ft. Along the north reach, the exposures typically are 20 to 50 ft long and 4 to 6 ft high.

Typical creek bank exposures in Little Bayou Creek, over both the south and north reaches, consist of massive silt overlying clay with the bed of the creek eroded into the clay member. These units are thought to consist of Upper Continental Deposits and loess, both Pleistocene in age. Little Bayou Creek appears to have more exposures of Holocene-age alluvial deposits than Bayou Creek. Like Bayou Creek, however, there are few areas where samples could be collected to ^{14}C age-date the sediments.

Faulting was not observed in any outcrops. Only one exposure contained features suggestive of paleoliquefaction. In this outcrop, located 3,162 ft north of PGDP "zero" north-south reference "latitude," a sand-filled fracture crosscuts the clay unit that is exposed in the creek bed, and discrete sand lenses appear to be present in the overlying silt unit that is exposed in the creek bank. It could not be determined if the fracture represented a diagenetic feature infilled with overlying sand or if it actually represented paleoliquefaction.

2.3.4 Barnes Creek Study

The regional Fault Study conducted at the Barnes Creek site (SAIC 2002) included a survey of faulting and related structures in the exposed banks of a 2,600-ft reach of the creek. This creek bank survey found no clear evidence of paleoliquefaction features. Investigators noted that characteristics of the geologic units were unfavorable to the formation of paleoliquefaction structures.

2.4 DEVIATIONS FROM THE PLANNED ACTIVITIES

During the Paleoliquefaction Study, there were two deviations from the Seismic Assessment Plan (BJC 2001a).

First, the scope of the ground inspection task was expanded to include a first-phase, continuous boat-based survey of the banks of the Ohio River. The goals of this survey included the following:

1. Assess the general suitability of Ohio River bank sediments for the Paleoliquefaction Study (age of exposed sediments and sequence of soil textures).

2. Locate syndepositional carbonaceous material (e.g., buried logs) for future collection of ^{14}C samples.

3. Identify large-scale paleoliquefaction features, if they exist.

4. Find promising areas for closer-look ground inspections.

This survey of the banks of the Ohio River provided a valuable regional perspective that could not be duplicated by any other data set. The Ohio River bank survey resulted in descriptions of 55 outcrops and photodocumentation of the riverbanks in the form of digital photographs and camcorder tapes.

Second, other than a survey of the banks of Bayou and Little Bayou Creeks on DOE property, the detailed ground inspection of selected areas within a 15-mile radius of PGDP was not performed. Given the initial delays in obtaining access agreements, results of the initial reconnaissance surveys, and preliminary results from work conducted at Barnes Creek and Site 3A, a decision was made by the DOE investigation team not to move forward with the final phase of the Paleoliquefaction Study.

2.5 DATA ACQUIRED

Attachments A-I (notes) and A-II (photodocumentation summary) of this technical memorandum document the results of the Ohio River bank survey. Attachment A-III documents the Mayfield Creek bridge survey. The notes of the walkdown of Bayou and Little Bayou Creeks are presented in Attachment A-IV.

2.6 SUMMARY OF RESULTS

The historical data review, Ohio River bank survey, and survey of soil exposures on Bayou and Little Bayou Creeks, accomplished most of the intent of the Paleoliquefaction Study. A large percentage of the available exposures of Holocene soils, across the 15-mile radius of the study area were observed during the Ohio River bank survey. The walking survey of Bayou and Little Bayou Creeks further assessed the immediate PGDP area.

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ATTACHMENT A-I

NOTES FROM THE OHIO RIVER BANK SURVEY

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OHIO RIVER RECONNAISSANCE

U.S. DEPARTMENT OF ENERGY
DOE OAK RIDGE OPERATIONS
PADUCAH GASEOUS DIFFUSION PLANT

BECHTEL JACOBS COMPANY LLC
MANAGED FOR THE US DEPARTMENT OF ENERGY UNDER US GOVERNMENT CONTRACT DE-AC-05-98OR22700
Oak Ridge, Tennessee Paducah, Kentucky Portsmouth, Ohio

Science Applications International Corporation
P.O. Box 2502
Oak Ridge, Tennessee 37831

FIGURE No. C5BC90001SK506.apr
DATE 05-08-02

Riverbank Classification Scheme

Vegetative cover		Exposure height	
Density (%)	Rating	(Height) ft	Rating
0 – 10	A	>6	1
10 – 33	B	3 – 6	2
33 – 67	C	1 – 3	3
>67	D	0 – 1	4

Ohio River Bank Survey

Site #	Description	Liquefaction feature[a]	Carbon age datable material[a]	Latitude/ longitude[a]
	October 9, 2001 Survey			
1	A2 at water edge, D1 overall bank rating: Modern river sediments cover most of bank, heavy vegetation.	–	–	–
2	A1: 50 ft long: 12-to-15-ft exposure of clay and silt units beginning at water's edge overlain by 3-ft exposure of silty clay(?). Veneer of modern river sediments cover most of bank.	–	–	–
3	A/B1: Clayey units exhibiting bedding. Appears to be channel deposit or slump feature. Bedding features suggest material is Quaternary (assuming that good bedding features are uncommon in McNairy Formation clay units). Note: similar exposures are covered by veneer of modern river sand upriver.	–	Tree stumps, apparently growing on clay bank.	–
4	A/B1/2: Similar clayey deposits.	–	Tree stumps that may be syndepositional	–
Upriver of 4	Log apparently protrudes horizontally from sediments just upriver in small creek tributary.	–	Syndepositional log	–
Upriver of 4	A1/2: Sediment exposures are covered by veneer of river sand near the I-24 bridge.	–	–	–
5	Discontinuous exposures of clay units. Largely covered by veneer of modern river sand.	–	–	–
6	Approximately 600 ft east of the I-24 bridge, approximately 2 ft above the water line. (Note: the river stage at Grand Chain is 16.5 ft.) Other than humic-rich layer (leaves and sticks), there is little other exposure of bank sediments. The riverbank is overlain by veneer of river sand.	–	0.5-to-1 ft humic layer	N37° 07.585' W088° 40.978'
From I-24 bridge to approx. 100 ft upriver of 7	A4: Discontinuous exposures of clayey beds, typically less than 1 ft thick.	–	–	–
7	A3/4: Thin sand horizon (0.2-to-0.3 ft) in exposure of clay units (1-to-1.5 ft). The presence of cross bedding and rounded clay clasts in the sand indicates the sand is not a liquefaction feature.	–	–	–
Upriver of 7	No exposure of bank sediments on Ohio River. Banks of Perkins Creek apparently offer good exposure of sediments.	–	–	–
8	A1: 150-to-200 ft long: Modern river sand covers the bottom 10-to-15 ft of bank sediments, overlain by 15 ft exposure of silt unit.	–	–	–
Downriver to Fort Massac	Exposures of riverbank sediments are poor to absent.	–	–	–
9	B/C/D1: 100-10-200 ft long: Clayey units protruding through veneer of modern river sediments.	–	–	–

Ohio River Bank Survey (continued)

Site #	Description	Liquefaction Feature[a]	Carbon Age Datable Material[a]	Latitude/ Longitude[a]
10	C/D1 overall bank rating: Approximately 1-ft clayey unit exposed. Sand found 'sandwiched' in clay unit. Sand contained no evidence of liquefaction origin.	–	–	–
Downriver of 10 to 300 ft upriver of railroad bridge	D4	–	–	–
Beginning 300 ft upriver of railroad bridge	A/B3: 1-to-3 ft exposure of clay units.	–	–	–
11	D3/4 overall bank rating: A1 rating for east bank of tributary on west side of railroad bridge: 15-ft exposure showing bedding features. No evidence of liquefaction features or material for carbon age dating.	–	–	–
11 to 12	No exposure.	–	–	–
12	A3: 600 ft long: 1-to-2 ft clay unit upriver of Bayou Creek.	–	–	–
13	A3: 300 ft long: 3 ft clay unit overlain by 5-to-10 ft package of sandy units.	–	–	–
13 to 14	Gravel bars prevent assessment of riverbank.	–	–	–
14	A3: 300-to-600 ft long: 2-ft clay at water edge in 15-ft bank. Sediments overlying clay are covered by veneer of river sediments and leaf litter.	–	–	–
14 to 15	A1/2 exposures of clay, some with good bedding features evident, near Snake Slough and down river.	–	–	–
15	A2: 4-to-6 ft exposure of clay units exhibiting good bedding features. No evidence of liquefaction features.	–	Humic-rich layers possible	–
Up to 2,000 ft upriver of 15	A3: 1-to-2 ft exposure of clay units.	–	–	–
Upriver to 16	No exposure.	–	–	–
16	A2: 100 ft long: 3-to-4 ft exposure of clay units just upriver of Newton's Creek.	–	–	–
16 to 17	Dominantly no exposure, some A3/4 exposure, riverbank approximately 8 ft high.	–	–	–
17	A2: 60 ft long: 3-to-4 ft exposure of riverbank sediments.	–	–	–
17 to 19	A3: discontinuous 1-to-3 ft exposures of riverbank sediments.	–	–	–
18	No discernable landmarks.	–	Syndepositional log exposed in riverbank	N37° 13.002' W088° 55.667'
19	Small tributary on down river side of boat ramp.	–	1-ft humic-rich layer near water level	N37° 12.998' W088° 56.246'

Ohio River Bank Survey (continued)

Site #	Description	Liquefaction Feature[a]	Carbon Age Datable Material[a]	Latitude/ Longitude[a]
Across river from 19	B4	–	–	–
Downriver of 20	Very poor to no exposure of bank sediments.	–	–	–
20	D1: 300 ft long: silt unit exposed in river bluff.	–	–	–
20 to 21	Very poor to no exposure of bank sediments.	–	–	–
21	Same as Site 20.	–	–	–
21 to 22	Very poor to no exposure of bank sediments.	–	–	–
22	A1: Greater than 6-ft exposure of sediments in creek bank.	–	–	–
22 to EEI Plant	Very poor to no exposure of bank sediments.	–	–	–
EEI Plant	A3: 2-ft clay .	–	–	–
EEI Plant to 23	Very poor to no exposure of bank sediments.	–	–	–
23 to 4,000 ft upriver	B/C2: Discontinuous, 50-ft long, 4-ft exposures of bank sediments.	–	–	–
Upriver to Fort Massac	Very poor to no exposure of bank sediments.	–	–	–
	October 10, 2001 Survey			
Paducah boat ramp to Irvin Cobb (Brookport) Bridge	Discontinuous A/B4: <100 ft long: <1-ft exposure of sand and clay units, typically no exposures of riverbank sediments are present.	–	–	–
Irvin Cobb (Brookport) Bridge to 24	Discontinuous A/B2/3/4: 1-to-3-ft exposures of riverbank sediments near water's edge. No obvious liquefaction features or material for carbon age dating.	–	–	–
24 to 25	Little-to-no exposure of riverbank sediments.	–	–	–
25	A4: <1-ft clay exposure at water's edge. Downed tree buried in clay unit suggests clay was deposited within last year. No obvious liquefaction features.	–	–	–
26	A/B2/3: 200 ft long: 3-ft clay unit: No obvious liquefaction features or material for carbon age dating.	–	–	N37° 07.015' W088° 39.186'
Downriver of 26	Very poor to no exposure of bank sediments.	–	–	–
Up to 1,500 ft up river of Dam 52 on Illinois bank	B/C1: 8-to-10 ft exposure of silt unit.	–	–	–
Northeast bank of Owens Island	Covered in rip rap.	–	–	–
Livingston Point east to Longitude W088° 33.1'	Exposed bank is 4-to-6-ft high sandy slope covered by veneer of modern river sediments.	–	–	–

Ohio River Bank Survey (continued)

Site #	Description	Liquefaction Feature[a]	Carbon Age Datable Material[a]	Latitude/ Longitude[a]
Livingston Point from Longitude W088° 33.1' to W088° 32.9'	A3: 1-to-3 ft of claycy units exposed near water's edge. No obvious liquefaction features. Only carbon-rich material appears to be tree stumps on clay bank.	–	–	–
Longitude W088° 32.9' to Site 27	Sandy riverbank sediments covered by veneer of modern river sediments.	–	–	–
27	A3: 1.5-ft clay unit exposed in riverbank. Plastic imbedded in clay.	–	Modern deposit	–
28	A1/2: 3-to-4-ft to 6-to-8-ft exposure of clayey units.	–	Wood imbedded in clay units – thought to be modern deposit	–
29	B/C2/3: 1-to-3-ft exposure of clayey units exhibiting bedding features.	–	–	–
29 to 30	Discrete B2/3 and B4 exposures of clayey units.	–	–	–
30	A/B2/3: approx. 500 ft long: 2-to-4-ft exposure of well-bedded clayey units. No obvious liquefaction features.	–	Syndepositional logs	–
31	A1: 10-ft sand deposit overlying silt unit, exposed in 20-ft river bluff, approximately 150 ft up river of Drake's Creek. Sand deposit contains cross bedding. No obvious vertical (liquefaction) features or buried paleosols.	–	–	–
31 to 32	B/C1	–	–	–
32	A1: 10-to-15-ft exposure of clayey riverbank sediments.	–	–	–
33	300-ft long exposure of riverbank sediments exhibiting good bedding features. No obvious cross-cutting liquefaction features.	–	Large syndepositional log near water's edge	N37° 03.788' W088° 28.248'
33 to 34	A/B2	–	–	–
34	A1: approximately 1,000-ft-long exposure: 25-to-30-ft exposure made up of 8 ft of gray, thick-bedded, clay units overlain by a thick sequence of well-bedded, laminar sand deposits.	–	Clay unit (near water's edge) with imbedded leaves and sticks	N37° 04.089' W088° 27.632'
Across river from 34	A1: 6-to-10-ft exposure of clayey units.	–	Vertical tree trunks – appears to be very recent sediment	–
35	A/B2: 4-ft exposure of clayey units containing imbedded plastic.	–	Modern sediment	–
35 to west end of Cottonwood Bar	Discontinuous A1 and A2 exposures of riverbank sediments. Plastic imbedded in sediments.	–	Modern sediment	–
West end of Cottonwood Bar	A1/2: exposure of riverbank sediments with imbedded plastic.	–	Modern sediment	–
North side of Cottonwood Bar	D1/2: no exposure of riverbank sediments.	–	–	–

Ohio River Bank Survey (continued)

Site #	Description	Liquefaction Feature[a]	Carbon Age Datable Material[a]	Latitude/ Longitude[a]
West end of Cottonwood Bar to approximate Longitude W088° 31.4'	Very poor to no exposure of bank sediments.	–	Several imbedded logs (and plastic) near water's edge	N37° 03.962' W088° 30.396'
Longitude W088° 31.4' to W088° 32.1'	A/B1/2	–	Vertically oriented log imbedded in sediments	N37° 04.180' W088° 32.196'
Longitude W088° 32.1' to W088° 32.5'	D1	–	3-to-5-ft exposures of sediments with imbedded logs	W088° 32.5'
Longitude W088° 32.5' to Site 36	B/C2: Barges prevent assessment of riverbank.	–	–	–
36	A1: 300 ft long: 20-ft exposure of clay, silt, and sand units.	–	Logs imbedded in sediments near water's edge	N37° 04.365' W088° 32.969'
36 to 37	Mostly D1.	–	–	–
37	B1/2: 3-to-6-ft exposure of riverbank sediments.	–	Vertically oriented logs imbedded in sediments. Appears to be a very recent sediment.	–
Site 37 to Longitude W088° 34.5'	Very poor to no exposure of bank sediments.	–	–	–
Longitude W088° 34.5' to W088° 35'	A2	–	–	–
Longitude W088° 35' to Site 38	Generally, very poor to no exposure of bank sediments.	–	–	–
38	A1: approximately 2,000 ft long: 10-ft exposure of riverbank sediments. No obvious liquefaction features.	–	–	–
300 ft downriver of Site 38	B2	–	–	–
To downriver side of Brookport	No exposure of bank sediments.	–	–	–
Approximate longitude W088° 38.6' to W088° 38. 8'	B/C1	–	–	–
	October 12, 2001 Survey			
39	A1: 200 ft long: 10-to-15-ft exposure of well-bedded (horizontal) riverbank sediments, silty clay grading to silt. No obvious liquefaction features or material suitable for carbon age dating.	–	–	N37° 05.534' W089° 09.014'

Ohio River Bank Survey (continued)

Site #	Description	Liquefaction Feature[a]	Carbon Age Datable Material[a]	Latitude/ Longitude[a]
Site 39 to Latitude N37° 06.182'	Very poor to no exposure of bank sediments. Gently sloping banks covered by a veneer of river sediments.	–	–	–
Latitude N37° 06.182' to N37° 07.275'	Very poor to no exposure of bank sediments.	–	–	–
Latitude N37° 07.275'	Poor exposure of riverbank sediments. Gently sloping riverbank covered by brown gravel and shells.	–	–	–
Latitude N37° 07.275' to Site 40	C1/2: 50 ft long: 6-ft high exposure of bank sediments at Hodges Creek.	–	–	N37° 07.701'
40 to 41	Very poor to no exposure of bank sediments.	–	–	–
41	A2: 200 ft long: 4-to-6-ft massive silt unit. No obvious liquefaction features or material suitable for carbon age dating.	–	–	N37° 08.207'
Site 41 to Latitude N37° 09.306'	Very poor to no exposure of bank sediments.	–	–	–
Latitude N37° 09.306'	Sloping riverbank. Upper bank deposit of uncemented gravel. Gravel appears to be of Continental Deposits origin. Thickness of gravel deposit uncertain.	–	–	–
Latitude N37° 09.306' to Site 42	Very poor to no exposure of bank sediments.	–	–	–
42	Gently sloping riverbank. Clayey unit near water's edge, overlain by gravel unit, overlain by sand unit, overlain by gravel unit. Gravel and sand may be a veneer of modern river sediments.	–	Clay unit near water's edge contains syndepositional sticks and logs	N37° 09.911' W089° 05.240'
42 to 43	A4: <1-ft clay at water's edge.	–	–	–
43	A1: 50 ft long: 20-ft bank exposure containing upper 12 ft silt unit. 3 horizons in upper silt unit (based on color).	–	–	N37° 10.061' W089° 05.043'
300 ft upriver of Site 43	Dark gray clay (thickness undetermined), overlain by 0.5-to-0.8-ft light gray clay, overlain by approximately 2 ft of a river sand deposit. Basal dark gray clay is relatively well indurated and may be Porters Creek Clay. Lighter gray clay is relatively unindurated. A piece of geotextile occurs at the base of the sand deposit. No obvious liquefaction features are present.	–	Lighter gray clay contains carbonaceous material.	–
Upriver to Site 44	A4	–	–	–
44	Two 1-ft clay benches exposed in riverbank. Gravel deposit may occur between clay units. Appears to be a good site to search for liquefaction features.	–	–	N37° 10.458' W089° 04.617'

Ohio River Bank Survey (continued)

Site #	Description	Liquefaction Feature[a]	Carbon Age Datable Material[a]	Latitude/ Longitude[a]
44 to 45	Very poor to no exposure of bank sediments.	–	–	–
45	A2: 5-ft exposure of stream bank sediments on up river side of small stream tributary. Stream bank sediments appear to be silts and clays. Sediment exposure contains several thin (several inch) layer where loose sediments have weathered out. This potentially represents a buried ejected sand deposit. No evidence of cross-cutting liquefaction features.	Possible feature	Syndepositional logs. Note: vertical tree stumps on sediments exposed in riverbank suggest these sediments are very young.	N37° 11.378' W089° 03.427'
Upriver of Site 45	A1: 300-to-600 ft length: 6-ft exposure of silty/clayey riverbank sediments.	–	–	–
600 ft upriver of Site 45 to Site 46	Very poor to no exposure of bank sediments.	–	–	–
46	100-ft length of exposure of riverbank sediments.	–	–	N37° 11.668' W089° 03.086'
Site 46 to Dam 53	Very poor to no exposure of bank sediments.	–	–	–
Dam 53 to 4,000 ft downriver on Kentucky bank	A2/3: contains long, 2-to-3 ft exposure of clayey units near water's edge. No obvious liquefaction features.	–	–	–
Downriver to Latitude N37° 10.869'	Very poor to no exposure of bank sediments. Riverbank is sandy (may be a sand deposit or a veneer of modern river sand). Vertical tree stumps protrude through the sand.	–	–	N37° 10.869' W089° 03.355'
Latitude N37° 10.869' to Site 47	A3/4	–	–	
47	A3/4: 300 ft length: discontinuous, 1-ft exposure of clayey unit near water's edge. May be a good site to look for liquefaction features (none were apparent from the boat). Note: sand on the bank suggests liquefaction source beds may be present.	–	–	N37° 10.538' W089° 03.681'
47 to 48	A4	–	–	–
48	A3: 300 ft length: 2-to-3-ft clay unit near water's edge, overlain by apparent sand-silt-sand sequence (cumulative thickness of sand-silt-sand sequence is 6-to-8 ft), overlain by 4-to-6 ft silt unit. Appears to be a good area to look for liquefaction features (none were apparent from the boat).	–	Anticipate that carbonaceous material could be collected from lower clay unit.	N37° 10.332' W089° 03.955'
48 to 49	Intermittent A/B2/3.	–	–	–
49	A2: 120 ft length: very good exposure of silt/clay sediment units in riverbank. Sand occurs beneath lower clay unit (6 ft above water's edge). Note: sand deposit (approximately 0.5 ft thick) may be a sand blow deposit. No bedding features are evident in the sand deposit. Appears to be a very good location for more detailed look for liquefaction features (none evident).	Possible feature	0.1-ft horizon rich in leaf matter.	N37° 09.741' W089° 04.723'

Ohio River Bank Survey (continued)

Site #	Description	Liquefaction Feature[a]	Carbon Age Datable Material[a]	Latitude/ Longitude[a]
Downriver of Site 49	Discontinuous A3 exposures.	–	–	–
Latitude N37° 09.035'	A2/3: 600 ft length: near continuous exposures of clay units in riverbank.	–	–	–
Latitude N37° 09.035' to Site 50	Gravel bars prevent assessment of riverbank.	–	–	–
50	A1: great exposure (15-ft height) of fluvial silts and clays in south bank of Humphrey Creek. No liquefaction features or sand units are evident.	–	–	–
Site 50 to approximate latitude N37° 08.1'	Gravel bars prevent assessment of riverbank.	–	–	–
Approximate latitudes N37° 08.1' to N37° 07.4'	Very poor to no exposure of bank sediments.	–	–	–
Latitude N37° 07.197'	Apparent exposure of Porters Creek Clay.	–	–	N37° 07.197' W089° 06.063'
Latitude N37° 07 to latitude N37° 06.1	A1: 8-to-10 ft exposure of well-bedded, river bank sediments. Sand unit near water's edge overlain by silt and clay units.	–	Imbedded vertically oriented tree stumps. At least one log buried horizontally.	–
Latitude N37° 06.1 to Site 51	A/B2/3/4	–	–	–
51	A1: >300 ft length: 6-to-8-ft exposure of silt and clay units with thin sand interbeds.	–	–	N37° 05.845' W089° 07.485'
Site 51 to latitude N37° 01.899'	Very poor to no exposure of sediments in Kentucky bank.	–	–	–
Latitude N37° 01.899' to Site 52	Very poor to no exposure of sediments in Illinois bank – covered by rip rap.	–	–	–
52	B1: 300 ft length: 12-to15-ft exposure of clay and silt units. No obvious liquefaction features. No sand or gravel units. No buried logs are apparent.	–	–	N37° 03.750' W089° 10.599'
52 to 53	Barges prevent assessment of riverbank.	–	–	N37° 03.986' W089° 10.449'
53	Similar to Site 52.	–	–	–
West of 19	A4: Very small exposures of modern overbank deposits (primarily sands with some interbedded silts and clays.	–	–	–
54	A4: 300 ft length: <1-ft exposure of clay unit exhibiting good bedding features.	–	–	–
55	A1: Approximately 1,000 ft length: 12-ft exposure of 6-ft silt unit overlying 6-ft sand unit.	–	–	–

Ohio River Bank Survey (continued)

Site #	Description	Liquefaction Feature[a]	Carbon Age Datable Material[a]	Latitude/ Longitude[a]
Kentucky bank upstream of Lock and Dam No. 53	A2/3: Approximately 1,000 ft length: 3-ft high exposure of well-bedded clay unit locally containing 0.5-ft thick, cross-bedded sand.	–	Imbedded, vertically oriented sticks and logs	N37° 11.895' W089° 01.661'
Illinois bank 4,000 ft upriver of Lock and Dam No. 53	B3: 50 ft length: 2-to-3-ft exposure of silty unit.	–	–	N37° 12.700' W089° 01.793'
Illinois bank at river mile 961	A2: 100 ft length, 4-ft high exposure of well-bedded clay unit.	–	Imbedded horizontal log	N37° 13.094' W089° 00.996'
Illinois bank at Grand Chain Landing	B/C1: 200 ft length, 20-to-30 ft high exposure of silt in bluff located 100 ft from riverbank.	–	–	N37° 13.584' W088° 59.519'
Illinois bank 2,500 ft upriver of Grand Chain Landing	A1: 400 ft length, 30-ft high exposure of silt, containing 3 ft-thick gravel unit (located 10 ft above base of cliff).	–	–	N37° 13.735' W088° 59.107'
Illinois bank 5,400 ft up river of Grand Chain Landing	B/D1: 600 ft length, 20-ft high exposure of massive silt unit.	–	–	N37° 13.762' W088° 58.441'
Illinois at Post Creek Cutoff	- approximately 300 ft upstream from Ohio River: A1: 15-ft high massive silt overlying 5-ft high clay. - approximately 350 ft upstream from Ohio River: A1: 15-ft-high cut bank exposure: 2-to-3-ft high gravel unit near surface overlying 12-ft high massive silt unit overlying 3-ft high clay unit. Bedding features are evident locally in silt and clay units.	–	–	N37° 13.783' W088° 57.458' N37° 14.035' W088° 57.490'

[a]– None observed/recorded

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ATTACHMENT A-II

CAMCORDER AND DIGITAL PHOTOGRAPHIC DOCUMENTATION LOG OF THE OHIO RIVER BANK SURVEY

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Camcorder/Digital Photo Log of Ohio River Survey

Time	Bank	Landmark/description	Digital photo	Notes
		October 09, 2001 (Tape 1)		
0:00–7:18	KY	Across from Fort Massac	DP-1 and DP-2	Sites 1 (DP-1) – 3 (DP-3)
7:18–7:50	KY	Log downstream of I-24 bridge		
7:50–8:00	KY	Upstream of I-24 bridge		Site 5
8:00–10:28	KY	Humic layer between I-24 bridge and Lock 52 dam	DP-3 and DP-4	Site 6: Good C^{14} age date site
10:28–11:16	KY	Sand lens with cross-bedding downstream of Lock 52 dam	DP-5	Site 7
11:16–12:37	IL	15-ft exposure of silt unit downstream of Lock 52 dam	DP-6	Site 8
12:37–14:37	IL	Gravel exposed on river bank between I-24 bridge and Lock 52 dam		
14:37–16:30	KY	Sand layer in slumped block across from Metropolis		Site 10
16:30–18:00	KY	Bedded silts exposed in 15 ft high cut bank of tributary, downstream of Illinois Central Gulf Railroad bridge	DP-7	Site 11: Syndepositional board: 2" × 4" board with triangular cut
18:00–18:46	KY	Downstream of Illinois Central Gulf Railroad bridge		
18:46–19:52	KY	Upstream of Shawnee Steam Plant		
19:52–20:56	KY	Upstream of Bayou Creek		
20:56–22:00	KY	Bayou Creek, poor exposure		
22:00–23:11	KY	Longitude 88° 50.3"		Site 15
23:11–23:52	KY	Upstream of McCracken/Ballard County line boat ramp		Site 18: Two syndepositional logs
23:52–26:26	KY	At McCracken/Ballard County line boat ramp		Site 19
26:26–27:00	IL	Upstream of EEI power plant		
27:00–29:45	IL	Further upstream of EEI power plant, 4 ft high silt exposure		
29:45–30:13	IL	Downstream of Illinois Central Gulf Railroad bridge, 4 ft high clay/silt exposure		
30:13–30:33	IL	Bank exposure at Metropolis		
		October 10, 2001 (Tape 1)		
30:36–43:10	KY	Paducah boat ramp downstream to Irvin S. Cobb Bridge		
43:10–48:40	KY	Treefall buried in river bank, poor exposure		Site 25
48:40–52:07	KY	Downstream to Lock 52 dam		Site 26
52:07–54:10	IL	Upstream of Lock 52 dam		

Camcorder/Digital Photo Log of Ohio River Survey (continued)

Time	Bank	Landmark/description	Digital photo	Notes
54:10–56:50	IL/KY	Upstream to Irvin S. Cobb Bridge		
56:50–59:10	KY	Irvin S. Cobb Bridge to Paducah river front		
59:10–1:00:25	KY	Paducah industrial river front		
1:00:25–1:01:30	KY	Owens Island, bank covered by rip rap		
1:01:30–1:03:30	KY	Livingston Point, bank exposure of sand unit		
1:03:30–1:09:06	KY	Upstream of Livingston Point	DP-8	
1:09:06–1:10:30	KY	Upstream of Livingston Point		Plastic syndepositional with clay unit
1:10:30–1:14:00	KY	Further upstream of Livingston Point		
1:14:00–1:15:05	KY	Downstream of Crowel Landing	Near DP-9	Syndepositional logs
1:15:05–1:17:30	KY	Downstream of Drake Creek		Site 30: Syndepositional logs
1:17:30–1:20:30	KY	Upstream of Drake Creek, fluvial sand units exposure		Site 31
1:20:30–1:25:06	KY	Exposure of clay and silt units		Sites 32 and 33
1:25:06–1:30:00	KY	30 ft high exposure	DP-10/14	Site 34
		Tape 2 Begins		
0:00–2:10	IL	Upstream of Cottonwood Bar, silt and sand exposures		
2:10	IL	Upstream of Cottonwood Bar	DP-15	Site 35: Syndepositional plastic
2:10–5:50	IL	Upstream end of Cottonwood Bar, fluvial sand exposure		Syndeposiitonal plastic
5:50–8:52	IL	Downstream of Cottonwood Bar		
8:52–10:21	IL	Further downstream, exposure of silt	DP-16	Logs
10:21–13:50	IL	Further downstream		
13:50–16:00	IL	Across from Livingston Point, fluvial sand exposure	DP-17	Site 36: Logs
16:00–20:00	IL	Across from Livingston Point and Owens Island, poor exposure		
20:00–22:30	IL	Across from Owens Island, silt exposure		
22:30–24:20	IL	Across from Paducah, poor exposure		
24:20–26:00	IL	Upstream of Irvin S. Cobb Bridge, silt exposure	DP-18	Site 38
26:00–30:18	IL	Irvin S. Cobb Bridge to Lock 52 Dam, silt exposure		

Camcorder/Digital Photo Record of Ohio River Survey (continued)

Time	Bank	Landmark/description	Digital photo	Notes
		October 12, 2001 (Tape 2)		
49:40–53:40	IL	Mound City boat ramp, proceeding upstream		
53:40–56:48	IL	Gravel bar at Hodges Creek, Latitude 37° 07.2'		
56:48–1:00:34	IL	Upstream of Hodges Creek	DP-29/31	Site 41
1:00:34–1:05:15	IL	Gravel bar upstream of Hodges Creek		
1:05:15	IL	"B" bank exposure		Site 42: Wood
1:05:15–1:07:10	IL	Same as 1:00:34 – 1:05:15		
1:07:10–1:11:50	IL	Landslide area downstream of the Olmstead lock site	DP-32/33	Wood
1:11:50–1:16:30	IL	Downstream of the Olmstead lock site, excellent bank exposure	DP-34	Site 44
1:16:30–1:22:24	IL	No distinguishing landmark		
–	IL	Olmstead Lock and Dam Project	DP-35	
1:22:24–1:24:22	IL	Upstream of the Olmstead lock site to the Lock 53 dam		
1:24:22–1:25:00	IL/KY	No distinguishing landmark		
1:25:00–1:30:00	KY	Downstream of the Lock 53 dam		
		Tape 3 Begins		
0:00–1:44	KY	Downstream of the Lock 53 dam		
1:44–8:18	KY	N37° 09.741', W089° 04.723'	DP-36/38	Site 49: Syndepositional organic material, suspect sand blow
8:18–10:00	KY	No distinguishing landmark		
10:00–12:00	KY	Humphrey Creek	DP-39/42	Site 50
12:00–13:45	KY	Gravel bars at Humphrey Creek	DP-43	
13:45–21:30	KY	No distinguishing landmark		
–	KY	No distinguishing landmark	DP-44	
21:30–23:00	KY	Exposure of sand unit in clay deposit	DP-45	Site 51
–	KY	No distinguishing landmark	DP-46	
23:00–25:15	IL/KY	No distinguishing landmark		
25:15–28:46	IL	Illinois bank exposure of clay and silt	DP-47/49	Site 52
–	IL	View from Mound City boat ramp	DP-50	

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ATTACHMENT A-III

NOTES FROM THE MAYFIELD CREEK BRIDGE SURVEY

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Notes from the Mayfield Creek Bridge Survey

Location	View	Description	Liquefaction feature/ carbon-14 age-datable material	Digital photo record
Mayfield Creek at US 51, south of Wickliffe	East	On south bank: heavily vegetated with intermittent exposures of creek bank sediments On north bank: 50-100 ft long, 6-8 ft high exposure (B/C1)	None apparent	None
	West	On south bank: 100-300 ft long, 4-6 ft high exposure (A/B1/2); bank contains some sandy units; lateral bedding features are apparent; color suggestive of large, vertical cross-cutting feature On north bank: heavily vegetated with no exposure of sediments	South bank: potential sand blow deposit; large, horizontal log, ~2 ft above water line with 3-4 ft of overlying sediments may be syndepositional	DP19
W. Fork Mayfield Creek at US 62, east of Bardwell	North	Poor exposure of bank sediments; apparently consist of silt and clay	None apparent	None
	South	Similar to south creek banks	None apparent	None
Mayfield Creek at KY 121	East	Poor exposure of bank sediments, heavily vegetated	None apparent	None
	West	Poor exposure of bank sediments, heavily vegetated	None apparent	None
Several small creeks on KY 1837 between Blandville and Lovelaceville	North and South	Typically no exposure of creek bank sediments	None apparent	None
Mayfield Creek at US 62 south of Lovelaceville	East	Poor exposure of bank sediments, heavily vegetated	None apparent	None
	West	Similar to east creek banks	None apparent	None
Mayfield Creek at KY 339 north of Melber	East	Poor exposure of bank sediments, heavily vegetated	None apparent	None
	West	Similar to east creek banks	None apparent	None
Mayfield Creek KY1241	Northwest	4-6 ft high creek banks; creek banks are heavily vegetated but with occasional 50-100 ft long exposures; creek bank sediments appear to be clayey silt	None apparent	None
	Southeast	4-6 ft high creek banks; creek banks are heavily vegetated but with occasional 50-100 ft long exposures; creek bank sediments appear to be clayey silt	None apparent	None
Mayfield Creek at US 45 south of Lone Oak	Northwest	Poor exposure of bank sediments, heavily vegetated	None apparent	DP22 DP23
Mayfield Creek at US 45 south of Lone Oak	Southeast	200 ft long, near continuous, 6-9 ft high exposure; creek bank sediments appear to be silty; color suggests small sand units "sandwiched" into silts; laminar bedding planes apparent in uppermost exposure	Possible sand blow deposits	None
Mayfield Creek at KY 849 west of Boaz	North	10 ft high creek banks; poor exposure of bank sediments, heavily vegetated	None apparent	DP20
	South	10 ft high creek banks; poor exposure of bank sediments, heavily vegetated	None apparent	None
Mayfield Creek at KY 408 east of Viola	North	6–8 ft high creek banks; poor exposure of bank sediments, heavily vegetated; creek bank sediments appear to be silty	None apparent	DP21
	South	6–8 ft high creek banks; poor exposure of bank sediments, heavily vegetated; creek bank sediments appear to be silty	None apparent	None

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ATTACHMENT A-IV

NOTES FROM THE WALKDOWN OF BAYOU AND LITTLE BAYOU CREEKS

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Bayou and Little Bayou Creeks Bank Classification Scheme

Vegetative cover		Exposure height	
Density (%)	**Rating**	**(Height) ft**	**Rating**
0–10	A	>6	1
10–33	B	3–6	2
33–67	C	1–3	3
>67	D	0–1	4

Bayou Creek Survey

Plant north	Latitude	Longitude	Bank rating	Lithologic description	Paleoliquefaction/ Structural Features
-8070	NA	NA	A2 – West	25 ft long exposure; Gravel (50%), poorly sorted, rounded-to-subangular, in silt matrix; some iron cemented horizons (~ 0.3 ft thick)	None
-8020	NA	NA	A3 – West	~3–4 ft long exposure; Sand, medium, well sorted; with gravel layers (0.1 ft thick)	None
-8000	NA	NA	B2 – West	Silt, sandy (~3 ft thick), Recent, with contorted lamination – appears to be soft sediment deformation; over Gravel, silty	None
-7920	NA	NA	C2 – West	Silt, sandy with veneer of mud; appears to be creek sediment	None
-7800	NA	NA	B2 – West	15-ft long exposure; Silt, possibly Holocene alluvium (bedding units ≅ 0.1–0.2 ft thick); over Gravel, cemented; silt appears to be creek sediment	None
-7775	NA	NA	None	No exposure of creek bank sediments along trend of channel	Deep, 6-ft wide, channel cutting across creek, appears to be structurally controlled
-7750	NA	NA	A2/3 – West	50 ft long exposure; Gravel, cemented	None
-7500 to -7250	NA	NA	B/C-2/3 – East C1/2 – West	Gravel, cemented (~1 ft thick); over Silt	None
-7000	NA	NA	A2 – East	Silt, creek sediment; over Gravel (1.5 ft thick); over Silt, (1 ft thick)	Some occurrences of lower silt 'displaced' into gravel, mode of emplacement unclear
-6700	NA	NA	A1/2 – West	100 ft long exposure; Gravel, cemented	Silt structures present in gravel unit; structures are ~1 ft in diameter and have an iron-cement rind; some gravel present in matrix, origin unclear
-6169	37° 6.257'	88° 49.333'	C2 (Silt) – East A2 (Gravel) – East	150 ft long exposure; Silt (4-6 ft thick), laminar bedding; over Gravel, cemented (3–4 ft thick)	Empty mold in cemented gravel measuring 0.5 ft in diameter and 1.5 ft high appears to be burrow structure, same as silt structures observed earlier
-6111	37° 6.272'	88° 49.335'	B/C1 – West	20 ft long, 8 ft high exposure; Silt, well bedded (6–7 ft thick); over Gravel (0.5–1.0 ft thick)	None

Bayou Creek Survey (continued)

Plant north	Latitude	Longitude	Bank rating	Lithologic description	Paleoliquefaction/ Structural Features
-5832	37° 6.313'	88° 49.316'	A2 – East	15 ft long, 3 ft high exposure; Gravel, cemented	None
-5670	37° 6.343'	88° 49.317'	A2/3 – West	Small, 1-3 ft high exposure; Gravel	None
-5176	37° 6.420'	88° 49.292'	B1/2	200 ft long, 3-8 ft-high exposure; Gravel, clayey (3–4 ft thick); over Silt (6–8 ft thick)	None
-4991	37° 6.455'	88° 49.300'	None	Silt, poorly exposed, over Gravel, massive, grading upwards to thinly bedded sand/silt/gravel sequence	None
-4830	37° 6.487'	88° 49.307'	West	30 ft long, 12 ft high exposure; Silt, thick horizontal bedding; over Gravel; Note: Gravel exposure (A2) in west creek bank upstream	None
-4562	37° 6.528'	88° 49.290'	East	220 ft long exposure; Silt (up to 6 ft thick), internal laminar bedding within thickly bedded (1–3 ft thick) sub-units; over Gravel, iron cemented, with sand and silt interbeds. Sand interbeds have no internal structure other than thin silt layers that bound the upper and lower surfaces of the interbeds. In upstream exposure, sand interbeds occur throughout the exposed thickness of the gravel. In downstream exposure, sand interbeds occur predominantly at the top of the gravel.	Sand interbeds are potential liquefaction features but appear to be bedding/'loading' structures
-4395	37° 6.566'	88° 49.311'	West	10 ft high exposure; Silt (4–5 ft thick), massive; over Sand (2 ft thick), massive; over Gravel (0.3 ft thick); over Sand and Silt sequence grading downwards to Gravel (4 ft thick)	None
-4107	37° 6.620'	88° 49.328'	A2 – East	50 ft long, 3–4 ft high exposure; Gravel, cemented; furthest upstream exposure of Porters Creek Clay (in creek bed)	None
-3875	37° 6.680'	88° 49.389'	East	Some Gravel, cemented; over Porters Creek Clay in creek bed	None
-3768	37° 6.699'	88° 49.407'	Creek Bed	150 ft long exposure, near continuous, Porters Creek Clay in creek bed	See note below
-3753	37° 6.708'	88° 49.421'	Creek Bed	Porters Creek Clay in creek bed	Zone of sub-vertical fractures trending 130°, ~0.5 ft wide, at least 3 prominent fracture traces (parallel)

Bayou Creek Survey (continued)

Plant North	Latitude	Longitude	Bank Rating	Lithologic Description	Paleoliquefaction/ Structural Features
-3210	37° 6.798'	88° 49.403'	A2 – West	100–200 ft long, 4–5 ft high exposure; Gravel, cemented (2–3 ft thick); over Porters Creek Clay, weathered (2 ft thick)	Possible 3 ft-wide graben with gravel down dropped at least 1 ft. (Structure may also be slump block.) Edges of "graben" appear to coincide with linear fractures in Porters Creek Clay in creek bed
-2667	37° 6.888'	88° 49.388'	A2 – East	50 ft long, discontinuous exposure; Gravel and Silt, Recent? sediments (2 ft thick); over Gravel, cemented (3–4 ft thick), locally containing 1.5 ft thick lens of silt or sand; over Porters Creek Clay in creek bed	None
-2052	37° 6.993'	88° 49.387'	A2 – East	50 ft long exposure; Gravel, iron cemented (1.5–2 ft thick); over Clay, sandy, gravelly (2 ft thick)	None
-1798	37° 7.043'	88° 49.396'	B1 – East	Small, 12 ft-high exposure; Silt, (8 ft thick); over Gravel, cemented (4 ft thick)	None apparent. Veneer obscured bedding in silt
-1698	NA	NA	A2 – East	Silt, dark brown, possibly Holocene alluvium; over Gravel, iron cemented (3 ft thick); over Clay, (1.5 ft thick)	None
-1618	37° 7.088'	88° 49.436'	A2 – West	6 ft long, 3.5 ft high exposure; Silt, bedded; contains apparent 0.1-ft-thick, humic-rich layer located ~1.2 ft above water line. Note: exposure of Silt and Gravel located 50 ft downstream	None
-1355	37° 7.136'	88° 49.440'	A2 – West	200 ft long, 3 ft-high exposure; Gravel, cemented: over Clay; iron and manganese staining obscure bedding features	None apparent
-974	37° 7.204'	88° 49.456'	A/B2 – West	150–200 ft long exposure; Gravel, cemented (4 ft thick); over Clay (in bed of creek and 1.5–2 ft thick on north end of exposure); iron and manganese stains common	None
-652	37° 7.267'	88° 49.467'	A2 – East	100 ft long, 3 ft high exposure; Gravel; over Clay, weathered, retains bedding features	Fractures in clay
-241	37° 7.340'	88° 49.469'	A1 – West	300 ft long, near continuous, 5-8 ft high exposure; Silt, poorly exposed; over Gravel, iron cemented (3 ft thick), weathered surfaces suggest internal bedding; over Clay (4 ft thick), some sub-units with much gravel, weathered, poorly preserved bedding and abundant diagenetic "ball structures"	None

Bayou Creek Survey (continued)

Plant North	Latitude	Longitude	Bank Rating	Lithologic Description	Paleoliquefaction/ Structural Features
38	37° 7.381'	88° 49.447'	A2 – East	200 ft long, 5–6 ft-high exposure; Gravel, iron cemented (2–3 ft thick); over Clay (3 ft thick), containing lenses of gravel (up to 1 ft thick and 10 ft long), abundant diagenetic "ball structures" measuring 0.4–0.8 ft in diameter	None
209	37° 7.410'	88° 49.447'	A2 – West	100 ft long, 4–5 ft high exposure; Gravel, iron cemented; over Clay, heavily weathered; Note: exposure contains north end of gravel channel – south end of gravel channel found 100 ft upstream	None

NA = Not applicable; global positioning satellite readings were taken at this location.

Little Bayou Creek Survey

Plant north	Latitude	Longitude	Bank rating	Lithologic description	Paleoliquefaction/ Structural Features
-7046	37° 5.795'	88° 48.275'	D1	No exposure, main branch of Little Bayou Creek at south DOE property boundary	None
-6661	37° 5.918'	88° 48.456'	D1	No exposure, west tributary of Little Bayou Creek at southwest terminus	None
-4426	37° 6.212'	88° 48.118'	Creek Bed	30 ft length exposure; **Soil**, possibly Holocene alluvium (3-4 ft thick); over **Clay** (1 ft thick), heavily weathered	None
-1966	37° 6.510'	88° 47.668'	West	20 ft long, 4 ft high exposure; **Soil**, possibly Holocene alluvium; over **Silt**, massive (1.0 ft thick); over **Soil** horizon (1.0 ft thick); over **Clay** (2 ft thick)	None
-821	37° 6.659'	88° 47.497'	B2 – West	6 ft long, 4 ft high exposure; **Clay**, weathered, mottled with large mottle structures of 0.5 to 0.7 ft diameter, no distinguishable bedding features	None
-264	37° 6.711'	88° 47.344'	B1 – East	30 ft long, 9 ft high exposure; **Silt**, massive (6 ft thick); over **Clay** (3 ft thick)	Vertical and sub-vertical fractures in clay
-85	37° 6.723'	88° 47.281'	A1 – West	50 ft long, 8 ft high exposure; **Sand**, medium, silty, grading upward to silt, massive (6.5 ft thick); over **Clay**, (1.5 ft thick) with upper weathered horizon (gravel-rich); Weathering and algal veneer obscured bedding features. Note: 6-8 ft high exposure of same sequence over next 200 ft downstream	None
2585	37° 7.142'	88° 47.093'	B/C1 – West	50 ft long, 7 ft high exposure; **Silt**, massive (6 ft thick); over **Sand and Gravel**-rich unconformity (0.3 ft thick), weathered zone; over **Clay**, heavily weathered (1.0 ft thick)	None
2663	37° 7.150'	88° 47.087'	B/C1 – East	75 ft long, 8 ft high exposure; **Silt**, clayey, possibly Holocene alluvium sediment; over **Silt**, massive (2 ft thick); over **Clay**, weathered (creek bed)	None
2838	37° 7.188'	88° 47.103'	A/B 2 – West	50 ft long, 4 ft high exposure; **Sand**, silty, with no obvious internal bedding features, possibly Holocene alluvium creek sediment, (1 ft thick); over **Clay**, massive, highly weathered (creek bed to 2.5 ft above water line)	None

Little Bayou Creek Survey (continued)

Plant north	latitude	longitude	Bank rating	Lithologic description	Paleoliquefaction/ structural features
3162	37° 7.233'	88° 47.074'	B1 – East	50 ft long, 8 ft high exposure; **Silt**, massive; over **Clay**, massive, weathered (creek bed to 2 ft above water line)	Sand-filled fracture, bearing 85°, crosses creek bed; in east bank at fracture, stratigraphy consists of **Silt**, massive; over **Sand lens** (0.3 ft thick); over **Silt** (0.3 ft thick); over **Sand lens** (0.5 ft thick); over **Clay**. Sand lenses have limited lateral extent. Note: **Sand Lenses** may also be present in **Clay**
3226	37° 7.239'	88° 47.057'	A2 – West	20 ft long, 3.5-4.5 ft high exposure; **Silt**; over **Sand Lens**, crossbedded, (0.8 ft thick); over **Clay**, massive, weathered (3-3.5 ft thick)	None
3339	37° 7.257'	88° 47.054'	B/C1 – East and West	100 ft long, 6-8 ft high exposure; **Creek Sediments**, Recent; over **Sand**, coarse, poorly sorted, grading upwards to **Silt** (locally, silt contains thin, coarse sand lenses); over **Gravel**, sandy (0.8-1.0 ft thick); over **Clay** (up to 1.5-2.0 ft above water line)	**Sand Lenses** are potential paleoliquefaction feature but appear to be common depositional feature
3390	37° 7.287'	88° 47.123'	A1 – West	150 ft long, 10-12 ft high exposure; **Silt**, thick (Weathering reveals bedding on the scale of 0.5-3 ft thick. Silt locally contains 0.5-3.0 ft thick sand units. Liesegang banding well developed in sand units and adjacent silts, obscuring bedding features.). Over **Clay**, gravelly, sandy (at water line), over **Clay** (in creek bed).	None
3518	37° 7.303'	88° 47.088'	A2 – West	25 ft long, 5 ft high exposure; **Silt**; over **Sand and Gravel** (2 ft thick); over **Clay**	None
4275	37° 7.441'	88° 47.104'	B3/4 – East and West	1 ft high exposure near water line; **Clay**, heavily weathered	None
4700	37° 7.519'	88° 47.118'	A2 – East and West	10 ft long, 4 ft high exposures on east, then west bank; **Silt**, massive (2 ft thick); over **Clay**, well bedded (2 ft thick), some slump deformation; gravel rich unconformity at top of clay	None
5227	37° 7.611'	88° 47.127'	B2	4-5 ft high exposure; **Clay**, weathered, no bedding features evident	None
5599	37° 7.673'	88° 47.113'	A2 – West	5 ft high exposure and in creek bed; **Clay**, weathered, grading upward to silt	None

Little Bayou Creek Survey (continued)

Plant north	latitude	longitude	Bank rating	Lithologic description	Paleoliquefaction/ structural features
6744	37° 7.896'	88° 47.186'	A2	5 ft long, 3.5 ft high exposure; **Gravel**, iron cemented (1 ft thick); over **Clay** (creek bed to 2.5 ft above water line)	None
6821	37° 7.917'	88° 47.217'	C/D1	8 ft high, 100 ft long exposure; **Creek Sediments**, possibly Holocene alluvium; over **Silt** (several feet thick); over **Clay** (in creek bed). Vegetation and veneer of creek deposits obscure thickness of units and structural features	None
7105	37° 7.970'	88° 47.221'	C/D2 – North	50 ft long, 4 ft high exposure; **Sand**, possibly Holocene alluvium; over **Sand**, gravelly (~1 ft thick); over **Clay**, highly weathered (creek bed to 1.5 ft above water line)	None
7271	37° 8.038'	88° 47.354'	A2 – South	5 ft long, 5 ft high exposure; **Sand**, possibly Holocene alluvium; over **Silt**, massive (3.5 ft thick); over **Clay**, weathered (at water line)	None

APPENDIX B

TECHNICAL MEMORANDUM FOR THE REGIONAL FAULT STUDY

Prepared by
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Oak Ridge, TN 37830

August 2002

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CONTENTS

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FIGURES

TABLES

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ACRONYMS

BJC	Bechtel Jacobs Company LLC
^{14}C	carbon-14
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DOE	U.S. Department of Energy
DPT	direct-push technology
EPA	U.S. Environmental Protection Agency
GPR	ground-penetrating radar
PGDP	Paducah Gaseous Diffusion Plant

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1. INTRODUCTION

Representatives and support staffs of the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Commonwealth of Kentucky, worked together to develop a field investigation program to address seismic issues associated with potentially siting a Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) waste disposal facility at the Paducah Gaseous Diffusion Plant (PGDP). These planning efforts for conducting the Seismic Investigation program at Site 3A are described in the *Seismic Assessment Plan for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant* (BJC 2001) and an evaluation of National Environmental Protection Act values (BJC 2002). The Seismic Investigation program consisted of three primary tasks: a Paleoliquefaction Study, a Fault Study, and a Geotechnical Study. These three tasks are documented in five technical memoranda.

This technical memorandum documents the regional Fault Study activities, which included a Barnes Creek bank study, a ground penetrating radar (GPR) survey, and a direct-push technology (DPT) survey. The planned test pits, and trenching activities that were originally planned as part of the regional Fault Study were determined to be unnecessary. The Barnes Creek site is located approximately 11 miles northeast of PGDP in Massac County, Illinois (Fig. B.1). The bank study, GPR survey and DPT survey activities were performed on private property at the Barnes Creek site. License agreements were executed with the private property owners to obtain permission for access to the property and to conduct ground intrusive activities.

2. BARNES CREEK BANK STUDY

The purpose of the Barnes Creek bank study was to observe and measure visible evidence of near-surface faulting in the bank of Barnes Creek.

2.1 PLANNED ACTIVITIES

The planned bank study activities are described in Sect. 3.2.1 of Part II of the Seismic Assessment Plan (BJC 2001) as follows:

> The bank study will consist of using hand tools to scrape weathered soil from the exposed face of the faults. Earthmoving equipment, such as a backhoe or bobcat, may be used if necessary. Approximately five to seven study areas are planned covering the exposures of the Westerman graben and terrace graben faults, each approximately 20 ft wide along the creek bank and extending from the bottom to the top of the creek bank. These study areas will focus on the known observed faults, but additional study areas may be identified by the subject-matter experts.
>
> Geological features that are discovered will be documented, photographed, and measured (strike, displacement, etc.). A total of up to seven samples of organic matter may be collected from the Barnes Creek study areas and sent to an approved off-site laboratory for ^{14}C age dating.

All regional Fault Study activities were conducted at the Barnes Creek site, which is located in Massac County, Illinois (Sect. 9, Township 15 South, Range 5 East)..

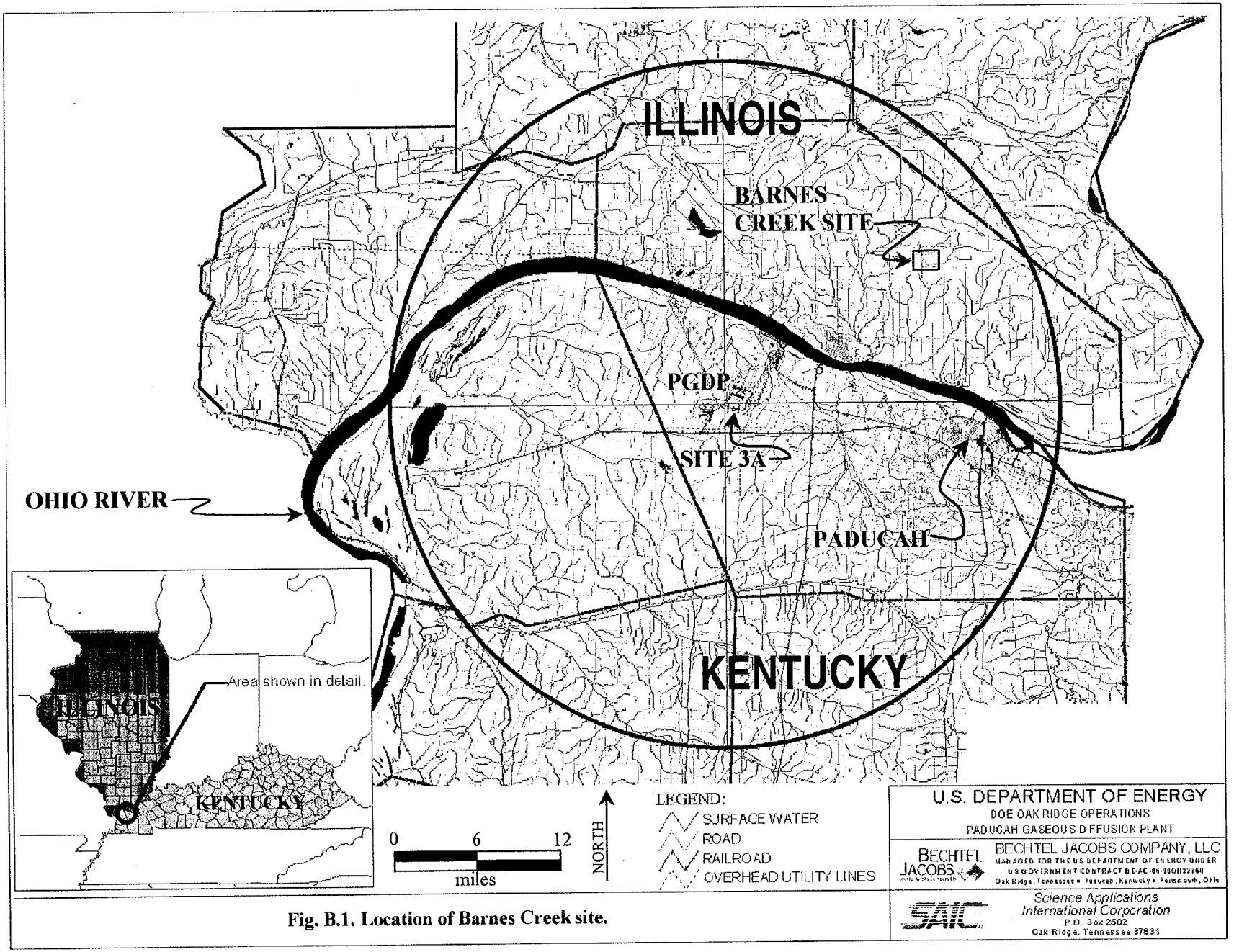

Fig. B.1. Location of Barnes Creek site.

2.2 SUMMARY OF WORK PERFORMED

The bank study was conducted at the Barnes Creek site on February 11–15, 2002. The bank study was performed by SAIC Engineering, Inc., and its subcontractors. SAIC is under subcontract to Bechtel Jacobs Company LLC (BJC), the DOE's Management and Integration contractor.

The study began at Barnes Creek Road and progressed eastward to Orchard Road. Station numbers were established as a distance from Barnes Creek Road (e.g., station 00+00). (Station 5+00 is 500 ft east of Barnes Creek Road, and station 11+82 is 1182 ft east of Barnes Creek Road.) The field crew identified the major geologic features in Barnes Creek, including the terrace graben and the Westerman graben. Twelve study areas were identified. After cleaning each area with hand tools, geologic features were examined and photographed. Strike and dip measurements were recorded and stratigraphic units were identified. Fourteen organic samples were collected for ^{14}C age dating, and the results are summarized in Table B.1. Laboratory data sheets are presented as Attachment B-IV. A large sample was split to possibly provide materials for pollen analysis in the event that a date using an independent method was required. Because the sample was successfully dated using ^{14}C age dating, the pollen analysis became unnecessary. Attachment B-I of this technical memorandum contains maps, geologic descriptions, and other data collected from the field.

2.3 DEVIATIONS FROM PLANNED ACTIVITIES

During the study, there were two deviations from the Seismic Assessment Plan (BJC 2001).

First, the plan called for "approximately five to seven study areas," but allowed for additional study areas to "be identified by the subject-matter experts." Twelve study areas were identified and examined. This deviation provided additional data, contributing to a more complete study of the bank.

Second, the plan called for "up to seven samples of organic matter" to be collected for ^{14}C age dating. Fourteen organic samples were collected, and an additional split sample was archived. The 14 samples were sent to the laboratory for analysis. The laboratory was able to analyze 10 of the samples. Again, this deviation provided additional data, contributing to a more complete study of the bank.

2.4 DATA ACQUIRED

Data acquired during the study are presented in Attachment B-I of this technical memorandum. The attachment includes a compact disc that contains maps, conceptual diagrams, photographs, and other records of the activities that were conducted.

2.5 SUMMARY OF RESULTS

The Barnes Creek bank study produced a complete and highly detailed record of the features expressed along the banks of Barnes Creek. The results of the ^{14}C analyses on samples collected will be used to determine the age of the most recent faulting at the Barnes Creek site. The information gathered during this study will be used to support the results of the site-specific Fault Study conducted at PGDP at Site 3A.

Table B.1. Summary of Barnes Creek bank study organic sampling and ^{14}C age dating

Sample number	Barnes Creek station	Depth from top of bank (ft)	Stratigraphic location	Implications/significance	Measured radiocarbon age[a]	Conventional radiocarbon age[a]
CCFRBS-01	11+82	5.9	Near base of old "gray" alluvium.	Minimum age of older gray alluvial materials.	Insufficient carbon	3,630 ± 50 BP
CCFRBS-02	14+55	10	Silt layer in upper Metropolis.	Age of upper Metropolis.	Insufficient carbon	Insufficient carbon
CCFRBS-03	14+37	8.5	Base old alluvium or upper Metropolis.	Age of upper Metropolis.	Insufficient carbon	Insufficient carbon
CCFRBS-04	14+37	8.5	Base old alluvium or upper Metropolis.	Minimum age of upper Metropolis.	Insufficient carbon	Insufficient carbon
CCFRBS-05	14+37	8.5	Base old alluvium or upper Metropolis.	Minimum age of upper Metropolis.	NA - archived	NA - archived
CCFRBS-06	13+71	8.5	Young alluvium 3 in. above Metropolis; old alluvium few ft to east.	Minimum age of younger brown alluvial materials.	390 ± 50 BP	360 ± 50 BP
CCFRBS-07	04+61	4.0	6 in. above Metropolis in older gray alluvium.	Minimum age of upper Metropolis.	5,360 ± 50 BP	5,370 ± 50 BP
CCFRBS-08	04+61	5.0	0.7 ft into Upper Metropolis; possible root cast.	Minimum age of upper Metropolis.	5,010 ± 50 BP	5,000 ± 50 BP
CCFRBS-09	04+61	4.0	In upper Metropolis.	Age of upper Metropolis.	6,690 ± 50 BP	6,680 ± 50 BP
CCFRBS-10	07+82	6.0	Upper Metropolis in stratified alluvium.	Age of upper Metropolis.	5,410 ± 50 BP	5,410 ± 50 BP
CCFRBS-11	07+82	6.0	Upper Metropolis in stratified alluvium.	Age of upper Metropolis.	Insufficient carbon	5,700 ± 50 BP
CCFRBS-12	08+21	7.0	Upper Metropolis in old stratified alluvium.	Age of upper Metropolis.	5,410 ± 50 BP	5,400 ± 50 BP
CCFRBS-13	07+20	3.0	Young alluvium in draw 135 ft N of Barnes Creek.	Minimum age of younger brown alluvial materials.	190 ± 50 BP	180 ± 50 BP
CCFRBS-14	07+20	3.8	Young brown alluvium.	Minimum age of younger brown alluvial materials.	210 ± 50 BP	190 ± 50 BP

[a]Dates are reported as radiocarbon years before present (BP), where "present" is defined as 1950 A.D. (This table supercedes any draft information presented in Appendix A.)
NA = Not analyzed

3. GPR SURVEY

GPR is a nonintrusive electromagnetic geophysical survey method. A summary of this geophysical technique is presented in the Blackhawk GeoSciences GPR Calibration Study Report (SAIC 2002). The purpose of the GPR survey at the Barnes Creek site was to provide high-resolution data to better define potential faulting of the uppermost sediments and to refine the locations of the planned intrusive investigation activities.

3.1 PLANNED ACTIVITIES

The planned GPR survey activities are described in Sect. 3.2.2 of Part II of the Seismic Assessment Plan as follows (BJC 2001). "The survey will consist of three GPR lines. Each of the three GPR lines will be 500 ft long. A maximum 50 MHz GPR is planned; the actual frequency may be modified based upon the results of the calibration survey."

During the January 15, 2001, meeting, DOE, EPA, and the Commonwealth of Kentucky reviewed the results of the previous GPR calibration survey and agreed that a 200 MHz antenna would be used (SAIC 2002).

3.2 SUMMARY OF WORK PERFORMED

The GPR Survey was conducted on February 12, 2002 in the expected terrace graben area, approximately 1,100 ft north of Barnes Creek (as depicted in Nelson et al. 1998). The locations of the three parallel survey lines are shown in Fig. B.2. The GPR survey was performed by SAIC and its subcontractor, Blackhawk GeoServices. SAIC is under subcontract to BJC, DOE's Management and Integration contractor. Blackhawk GeoServices processed the data, and that report is contained in Attachment B-II of this technical memorandum. The Blackhawk GeoServices report contains detailed information regarding the data acquisition, data processing, and interpretation of results.

3.3 DEVIATIONS FROM PLANNED ACTIVITIES

During the GPR Survey, there were two deviations from the Seismic Assessment Plan (BJC 2001). First, the Seismic Assessment Plan called for three parallel lines to be conducted, totaling approximately 1,500 ft. Three 900-ft lines, totaling 2,700 ft, were established for the GPR survey. This configuration provided more data than initially planned. Second, the Seismic Assessment Plan contained a figure that illustrated or noted that two of the planned lines would be oriented perpendicular to the expected terrace graben faults (e.g., northwest-southeast orientation), and one line would be oriented east-west. The three GPR lines were surveyed with an east-west orientation. This configuration allowed more data to be collected from the area with no overlap.

3.4 DATA ACQUIRED

The results of GPR survey are presented in Attachment B-II of this technical memorandum. The attachment consists of the GPR Study Report prepared by Blackhawk GeoServices and contains processed data from each survey line.

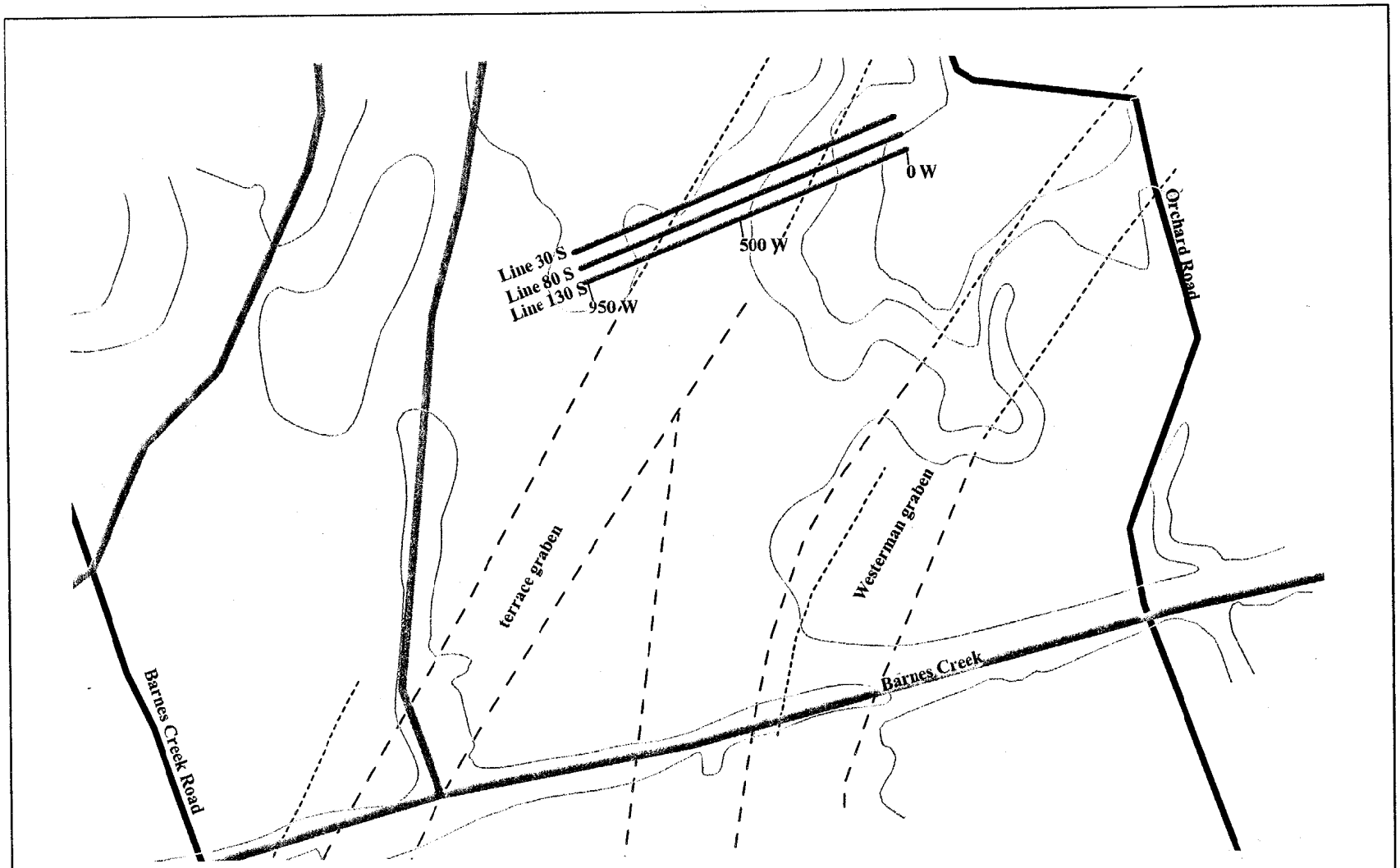

Fig. B.2. Locations of GPR survey lines at the Barnes Creek study area.

3.5 SUMMARY OF RESULTS

The resolution of the GPR survey data was considered adequate to locate the initial DPTs. The results of the GPR survey also were used (along with the results of the initial DPTs) to refine subsequent DPT locations. This survey provided high-resolution data of the uppermost sediments and allowed investigators to identify where the loess was present and absent. This data allowed the locations of the DPTs to be refined.

4. DPT SURVEY

DPT is an intrusive method for collecting continuous subsurface soil core samples. The DPT advances a small diameter core barrel (approximately 2 inches) by means of a hydraulic ram and/or hydraulic hammer. Although somewhat depth-limited (approximately 50 ft at the PGDP), the DPT, when compared to conventional drilling methods, is fast, convenient, and generates minimal waste by-products.

The purpose of the DPT survey was to collect soil cores to identify faults and/or displacement of unconsolidated units at relatively shallow depths. Ideally, the DPT cores would allow evaluation of stratigraphy and observation of disrupted bedding, and would contain organic samples that could be collected for ^{14}C age dating. Additionally, results of the DPT survey would be used to support decisions regarding the remainder of the intrusive activities (e.g., test pits and trenching).

4.1 PLANNED ACTIVITIES

The DPT survey activities originally planned in the terrace graben area are described in Sects. 3.2.3 of Part II of the Seismic Assessment Plan (BJC 2001) as follows:

> The DPT will allow continuous samples to be collected from the surface to the top of the Cretaceous sediments (McNairy Formation), which is anticipated to be up to 100 ft below ground surface... The DPT holes will be installed at two locations, approximately perpendicular to and intersecting the fault. Five DPT holes will be completed at each location, with one DPT hole located over the fault, and the remaining DPT holes located on each side of the fault. The DPT holes will be spaced approximately 50 ft apart... Up to four organic samples (total) may be collected from the DPT holes and sent to an approved off-site laboratory for ^{14}C age dating.

4.2 SUMMARY OF WORK PERFORMED

The DPT survey was performed by SAIC and its subcontractor, Gregg In Situ, Inc. SAIC is under subcontract to BJC, the DOE's Management and Integration contractor.

The DPT survey was conducted February 24 through March 8, 2002, with Gregg In Situ's 22-ton *RHINO* track rig. Ten 1.75 in.-DPTs were driven hydraulically along the middle GPR survey line (Fig. B.3). All DPT cores were placed in wooden core boxes, logged by a geologist, photographed, and subsequently placed in storage. Table B.2 contains a summary of the DPT survey activities. As shown in Table B.3, six organic samples were collected, and the laboratory was able to conduct ^{14}C age dating on five of the samples.

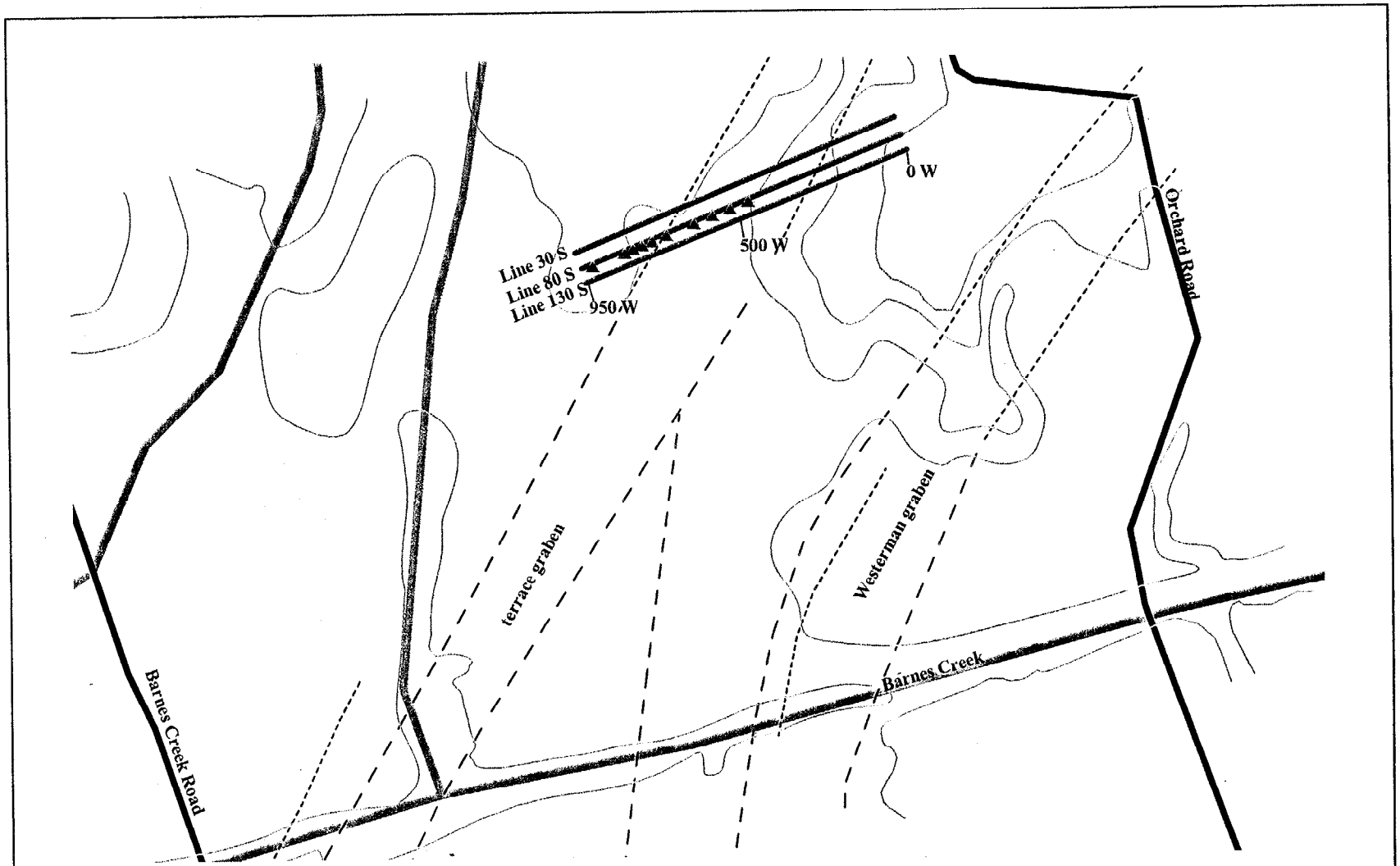

Fig. B.3. Locations of DPTs at the Barnes Creek study area.

Table B.2. DPT summary

DPT station (ft)	Relative elevations [a] (ft)	Total depth (ft bgs)	Date conducted
460	3.22	32.0	Feb. 19, 2002
510	4.12	32.0	Feb. 19, 2002
560	2.07	32.0	Feb. 19, 2002
610	0.32	32.0	Feb. 19, 2002
700	1.12	56.0	Feb. 21, 2002
736	0.95	63.5	Feb. 22, 2002
775	0.30	52.0	Feb. 21, 2002
800	1.00	32.0	Feb. 22, 2002
825	2.65	36.0	Feb. 18, 2002
910	0.00	36.0	Feb. 18, 2002

[a] Relative elevations are measured from the lowest DPT Station (i.e., station 910).

Table B.3. Summary of DPT organic sampling and ^{14}C age dating

Sample number	DPT station (ft)	Sample depth (ft bgs)	Measured Radiocarbon age[a] (years bp)	Conventional radiocarbon age[a] (years bp)
CCFRD460-1	460	3.5	1,160 ± 40	1,190 ± 40
CCFRD560-1	560	11.0	9,160 ± 50	9,200 ± 50
CCFRD560-2	560	6.0	Insufficient carbon	Not reported
CCFRD610-1	610	5.2	7,230 ± 40	7,260 ± 40
CCFRD736-1	736	43.7	11,130 ± 60	11,170 ± 60
CCFRD736-2	736	21.8	10,760 ± 50	10,800 ± 50

[a] Dates are reported as radiocarbon years before present (BP), where "present" is defined as 1950 A.D.

4.3 DEVIATIONS FROM PLANNED ACTIVITIES

During the DPT survey, there were three deviations from the Seismic Assessment Plan (BJC 2001).

First, the original plan called for "continuous samples to be collected from the surface to the top of the Cretaceous sediments (McNairy Formation), which is anticipated to be up to 100 ft below ground surface." This estimated depth was based on previous studies conducted in the area (Nelson et al. 1998). The McNairy was encountered in many of these DPTs, however, at approximately 14 ft to 40 ft bgs. (It is unclear whether the McNairy Formation was encountered in DPT station 775, which was advanced to a total depth of 52 ft.) Although the target horizon was encountered at shallower depths than anticipated, this "variation" from the plan did not affect the quality of the DPT survey.

Second, the original plan called for five DPTs to be completed at two locations (i.e., a total of 10 DPTs). The plan also called for the DPTs to "be spaced approximately 50 ft apart." Subsequent discussions with EPA and the Commonwealth of Kentucky, however, confirmed that the specific locations of the DPTs should be based on the results of the GPR survey and any other pertinent field data (such as previously drilled DPTs). The 10 DPTs were installed in the planned area of interest, but they were located on one line approximately 450 ft long. This deviation is thought to enhance the quality of the survey because the DPT survey results provided one comprehensive, cross-sectional view of the terrace graben area instead of two smaller views.

Third, the plan called for collecting "up to four organic samples (total)" for ^{14}C age dating. As shown in Table 3, six samples were collected, and the laboratory was able to conduct ^{14}C age dating on five of the samples. This deviation provided additional data and improved the quality of the DPT survey.

4.4 DATA ACQUIRED

The results of DPT survey are presented in Attachments B-III and B-IV of this technical memorandum. Attachment B-III contains the drilling logs, and Attachment B-IV contains the laboratory results of the ^{14}C age dating analyses.

4.5 SUMMARY OF RESULTS

The DPT survey was considered successful. It allowed soil cores to be collected, stratigraphy to be observed, and organic samples to be collected for ^{14}C age dating. Ten DPTs were pushed, and a total of 403.5 ft of core was collected. Six organic samples were collected, and the laboratory was able to analyze the data for five of the samples. Additionally, the results of the DPT survey were considered when determining if the planned test pits and trench would be excavated in this area.

5. TEST PITS AND TRENCHING

As described in Sect. 3.2.4 of Part II of the Seismic Assessment Plan, three test pits were originally planned to be excavated to a maximum depth of 15 ft at a suspected terrace graben fault location to acquire visual evidence of any near-surface fault displacement (BJC 2001). As described in Sect. 3.2.5 of Part II of the Seismic Assessment Plan, one trench was planned to be excavated to a maximum depth of 10 ft perpendicular to a suspected terrace graben fault location to acquire visual evidence of any near-surface fault displacement (BJC 2001). The trench was to be constructed to allow personnel to enter and collect organic samples for ^{14}C age dating.

Based on the results of the DPT survey, the DOE investigation team determined that the test pits and trench would not be necessary. This decision was based on several factors. First, the DPT study indicated no correlation between surface topography and subsurface faulting. Second, the investigation team was able to collect several organic samples from Barnes Creek for ^{14}C age dating. Third, the most likely location of the pits/trench was in a shallow drainage swale; and excessive surface water may have allowed water to collect in the pits/trench or cause the pit/trench walls to collapse, creating additional safety concerns. Fourth, excavating pits and trenches would create a much greater physical disturbance than the other study techniques employed and would result in a higher probability of adversely impacting the property. This decision was conveyed to EPA and the Commonwealth of Kentucky (PPC 2002a, 2002b, 2002c, and 2002d).

6. REFERENCES

BJC 2002. *NEPA Considerations: Site-Specific and Regional Fault Studies and Acquisition of Seismic and Geotechnical Data*, Kevil, KY, February 13.

BJC (Bechtel Jacobs Company LLC) 2001. *Seismic Assessment Plan for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, BJC/PAD-207, Final, Bechtel Jacobs Company LLC, Kevil, KY, September.

Nelson, John W, F. Brett Denny, Leon R. Follmer, and John M. Masters 1998., "Quaternary grabens in southernmost Illinois: deformation near an active intraplate seismic zone," *Tectonophysics*, 305, pp. 381–397.

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PPC 2002b. "CERCLA Waste Disposal Options Project Seismic Investigation Program - Field Activities Summary," e-mail dated March 11.

PPC 2002c. "CERCLA Waste Disposal Options Project Seismic Investigation Program - Field Activities Summary," e-mail dated March 15.

PPC 2002d. "CERCLA Waste Disposal Options Project Seismic Investigation Program - Field Activities Summary," e-mail dated April 26.

SAIC (SAIC Engineering, Inc.) 2002. *Technical Memorandum for the Site-Specific Fault Study Initial Activities*, SAIC, July.

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ATTACHMENT B-I

BANK STUDY RESULTS

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ATTACHMENT B-II

GPR SURVEY RESULTS

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GROUND PENETRATING RADAR SURVEY REPORT

Barnes Creek Site, Illinois

Site 3A Seismic Assessment
Paducah Gaseous Diffusion Plant
Paducah, Kentucky

Blackhawk GeoServices Project No. 2901SAI

Prepared for

Science Applications International Corporation
151 Lafayette Drive
Oak Ridge, Tennessee 37830

Prepared by

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Oak Ridge, Tennessee 37830
(865) 483-0200

May 2002

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Figures

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) is the lead agency at the Paducah Gaseous Diffusion Plant (PGDP). The U.S. Environmental Protection Agency (EPA) and the Commonwealth of Kentucky pursuant to the Federal Facility Agreement (FFA) regulate environmental restoration activities at PGDP.

Over the past year, representatives from EPA, the Commonwealth of Kentucky, and DOE and their support staffs have developed a field investigation program to address seismic issues associated with potentially siting a CERCLA waste disposal facility at the PGDP (BJC 2001). The results of these investigations will be used as input to the feasibility study of disposal options for CERCLA-derived waste at PGDP. One of the potential disposal facility sites presently under consideration is referred to as Site 3A. This site is located on DOE property, south of the present security fence.

As part of this field investigation program, Blackhawk GeoServices (BHG) performed a ground penetrating radar (GPR) survey on February 12, 2002 approximately 800 feet north of Barnes Creek in Massac County, Illinois. The GPR survey was conducted in the northern portion of the same agricultural field where the GPR calibration study conducted in December, 2001 (Blackhawk 2002). The GPR calibration study results from Barnes Creek indicated that the 200-MHz antenna provided higher resolution and more useful data within the target zone of interest (i.e., the upper 5 to 10 feet of subsurface where near surface loess and/or fine-grained continental deposits are present). For the current phase of GPR work, data were acquired with the 200-MHz antenna along three east to west (E-W) oriented survey lines, each 950 feet in length.

The purpose of the Barnes Creek GPR survey is to determine whether a correlation exists between suspected near-surface faulting and elevated terraces and mounds within the study area. The largest terrace within the survey area is identifiable as a north-northwest (NNW) trending sharp topographic slope that divides the elevated eastern third of the site from the generally low-lying western area. The topographic slope is roughly linear in the area immediately south of the site, and the elevated section is approximately 10-15 feet higher than the low-lying area. The two mounds occur as subtle topographic features in the survey area. The "high" mound occurs in the eastern portion of the survey area and its elevation above the surrounding low-lying area varies from approximately 3 to 8 feet. The "low" mound occurs in the central portion of the site and its elevation above the surrounding low-lying area is approximately 2 feet.

This report summarizes the data acquisition and field methods used to conduct the GPR survey, and includes sections on data processing and GPR survey results.

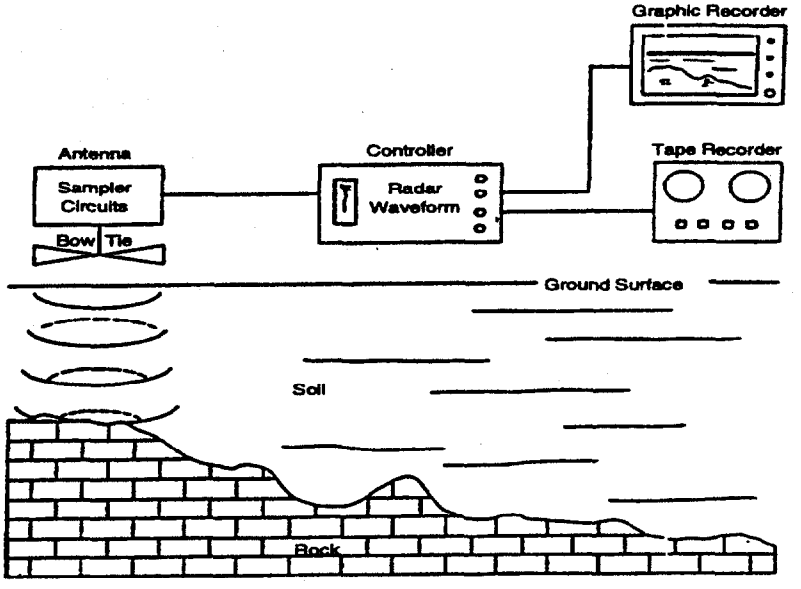
2.0 DATA ACQUISITION

This section describes the GPR method and field procedures used to conduct the Barnes Creek survey including survey control and production parameters.

2.1 GPR METHOD

GPR equipment used during this investigation consisted of a Geophysical Survey Systems, Inc. (GSSI) Model SIR-2P equipped with 200-megahertz (MHz) monostatic antenna, and a DPU-5400 high-resolution thermal gray-scale printer.

When conducting a GPR survey, an antenna containing both a transmitter and a receiver is pulled along the ground surface. The transmitter radiates short pulses of high-frequency EM energy into the ground. The EM wave propagates into the subsurface at a velocity determined by the relative dielectric constant of the medium through which the wave travels. When the wave encounters the interface of two materials having different propagation velocities or some other electrical heterogeneity, such as soil and a fracture, a portion of the energy is reflected back to the surface (see diagram below). The contrast in velocity between the two media can be quantified by a reflection coefficient at the media interface. The magnitude of the reflection coefficient increases as the contrast in velocities increases; the coefficient sign is positive when the velocity increases at the interface and negative when it decreases. The reflected signal is detected at a receiver antenna, often as a characteristic triplet that is the result of the receiving antenna response and of multiples generated along the propagation path. The signal is transmitted to a control unit, displayed on a color monitor, and saved in the internal memory of the unit.



Schematic diagram of GPR operating system and EM signal reflection.

As predicted by Maxwell's equations for a propagating EM wave, two kinds of charge flow are generated by the associated alternating electric and magnetic fields (Ulriksen 1982). The charge flows are conduction and displacement currents. The conduction current term is predominant at lower frequencies, and conduction currents are used in the EM induction method. At the higher frequencies

used in the GPR method, the displacement current term becomes predominant because the high frequencies will set bound charges in motion, causing polarization.

The physical properties that describe the movement of charges by conduction and displacement currents are the conductivity and the dielectric constant of the medium, respectively. Conductivity is a measure of the ease with which charges and charged particles move freely through the medium when subjected to an external electric field. The dielectric constant, or its value normalized by the dielectric constant of free space called the relative dielectric constant, is a measure of how easily a medium polarizes to accommodate the EM fields of a propagating wave (Keller and Frischknecht 1966).

Although conductivity has a smaller effect on the transmission of EM waves emitted from a GPR unit, it has an important effect on the attenuation of the waves (Ulriksen 1982). Highly conductive media will attenuate the EM signal rapidly and restrict depth penetration to the first several feet. Highly resistive (poorly conductive) media allow deeper penetration. The frequency of the transmitted waves also affects the depth of penetration. Lower frequencies penetrate deeper but have lower resolution, whereas higher frequencies can resolve smaller objects and soil layers at the expense of depth penetration. At many sites in the Southeastern U.S., soils are relatively conductive and depth penetration is often limited to 5 feet or less.

In unconsolidated materials, conduction occurs predominantly through pore fluids (Keller and Frischknecht 1966). Therefore, changes in pore fluid content, porosity, permeability, and degree of saturation will affect reflected and refracted EM signals. Faults and fractures in unconsolidated sediments, in which there may be different compaction densities relative to the surrounding area, can be identified in this manner. Also, the edges of anomalous zones sometimes exhibit diffraction patterns as a result of the transmitting and the receiving antennae being unfocused but emitting and receiving from a 45-degree cone. The cone allows the radar to detect subsurface variations or anomalies that are ahead of it, placing them deeper in time. As the radar approaches the anomaly, the reflection becomes shallower, with the shallowest reflection occurring when the radar is immediately above the feature. An identical pattern occurs as the antenna moves away from the feature.

Applications of GPR include mapping near-surface geology and landfill boundaries, delineating pits and trenches containing metallic and nonmetallic debris, and locating buried pipes, drums, and UST's.

2.2 SURVEY CONTROL

Survey control was established at the Barnes Creek site using a 300-foot fiberglass tape and surveyor's paint to mark 10-foot stations along the three GPR survey lines. Wooden survey stakes were placed at the beginning and end of each survey line and labeled with local coordinates. The northernmost survey line, designated as Line 30S, was located approximately 30 feet south of the E-W trending woods line. Lines 80S and 130S were established roughly 80 and 130 feet south of the woods line, respectively. A white wooden fence that bounds the eastern end of the agricultural field was located approximately 225 feet to the east of the starting station of the lines (i.e., 0W). All three lines traversed the "terrace" along the eastern portion and crossed the mounds in the central and western portions of the site. Since elevation changes were significant along the survey profiles, elevation (Z) shots were surveyed at select stations. These elevation data were later used to facilitate data interpretation.

Once the survey lines were established and control points were marked, a detailed hand-sketched site map was drawn in the field. The map included any surface topographical features, changes in vegetation cover, or cultural features (e.g., fences and overhead utilities) along or near the GPR survey lines that could potentially affect the geophysical data. The map also included reference features, such as the woods line and intermittent streams that could later aid in reconstructing the line locations. All

pertinent reference information documented on the hand-sketched site map was translated to aerial photographs and a plan-view map of the site.

2.3 PRODUCTION PROCEDURES

A total of approximately 8,980 linear feet of GPR survey data were collected during the Barnes Creek GPR survey. This included multiple passes along select profiles to maximize signal quality and penetration, and to provide a useful measure of data repeatability. GPR data were recorded semicontinuously at 32 scans per second as the 200-MHz antenna was hand towed along the survey lines. Data file names were recorded on the data file tracking form. Data were viewed in real-time on the GPR system color monitor and printed in real time with a DPU-5400 high-resolution thermal gray-scale printer.

Following the investigation, GPR data were downloaded to a personal computer (PC), backed up on compact disks (CD), and are retained in project files.

3.0 DATA PROCESSING

No post-processing was performed on the GPR data collected at Barnes Creek. The processing steps used on the previously collected calibration study data did not noticeably enhance the data quality. The .DZT files were imported from the GPR unit to a PC and were displayed using Radan® for Windows NT software from GSSI. A grayscale color transform was chosen to maximize the signal to noise ratio (S/N) and reflected events, and the data were imported into CorelDRAW® for final display.

Prior to generating figures, the GPR data were screened so that line and station ranges and overall data quality could be assessed. The names of the files generated and processing parameters used were recorded on data processing forms. All completed data acquisition and processing forms and original plotted sections collected during the investigation are retained in project files.

4.0 RESULTS

Figures 1-6 represent the GPR profile data acquired during the Barnes Creek GPR survey. Data profiles for Lines 30S, 80S, and 130S are presented such that the each survey line is continuous on one panel **(Figures 1, 3, and 5)**. The profiles are also presented at an expanded scale to provide more detail **(Figures 2A-2B. 4A-4B, and 6A-6B)**. The profiles depict horizontal distance in feet versus two-way traveltime. Depths described herein have been estimated from the approximate relationship of 1 foot of depth per 7 nanoseconds (ns) of two-way traveltime. This standard relationship is found in EM wave velocity tables for various earth materials. The specific value chosen was based on near-surface soil characteristics observed at the site.

Data quality results vary significantly along each profile. Data acquired over low-lying areas of the site generally show increased depth of penetration and resolution **(Figures 1, 3, and 5)**. Where station elevations are higher (e.g., terrace and mounds), data quality are marked by strong signal attenuation. This response is so consistent in the records collected, that the spatial relationships of the mounds and terrace can nearly be mapped directly from the data. This type of GPR response is typical in areas where near surface soil types vary significantly. In the Barnes Creek data, the high-amplitude reflections observed in the low-lying areas are interpreted to be caused by locally high volumes of granular soils relative to locally higher volumes of fine-grained sediments, such as silts and clays, on the higher elevation terrace and mounds. Perhaps the best example of these varying signal strengths relative to topography can be seen in the Line 130S data **(Figure 5).**

In the Line 30S data **(Figure 1 through 2B)**, several parabolic reflections are evident below 50 ns, particularly from stations 0W to 300W. These "out-of-the-plane" reflections were confirmed in the field to be caused by nearby tree branches, some of which were overhanging the survey line. Another anomaly type that occurred very regularly in the data was that caused by a faulty GPR marker switch. These anomalies are seen at the 100-foot stations where the marker switch was signaled twice by the operator to identify those stations.

Based on the data collected, the only spatial feature that shows strong correlation are the signal strength variations caused by topographic features. In the area investigated, there are no identifiable anomalies that correlate between the survey lines and support near-surface faulting.

5.0 REFERENCES

BJC (Bechtel Jacobs Company, LLC), 2001, "*Seismic Assessment Plan for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, BJC/PAD-207 (Final), September.

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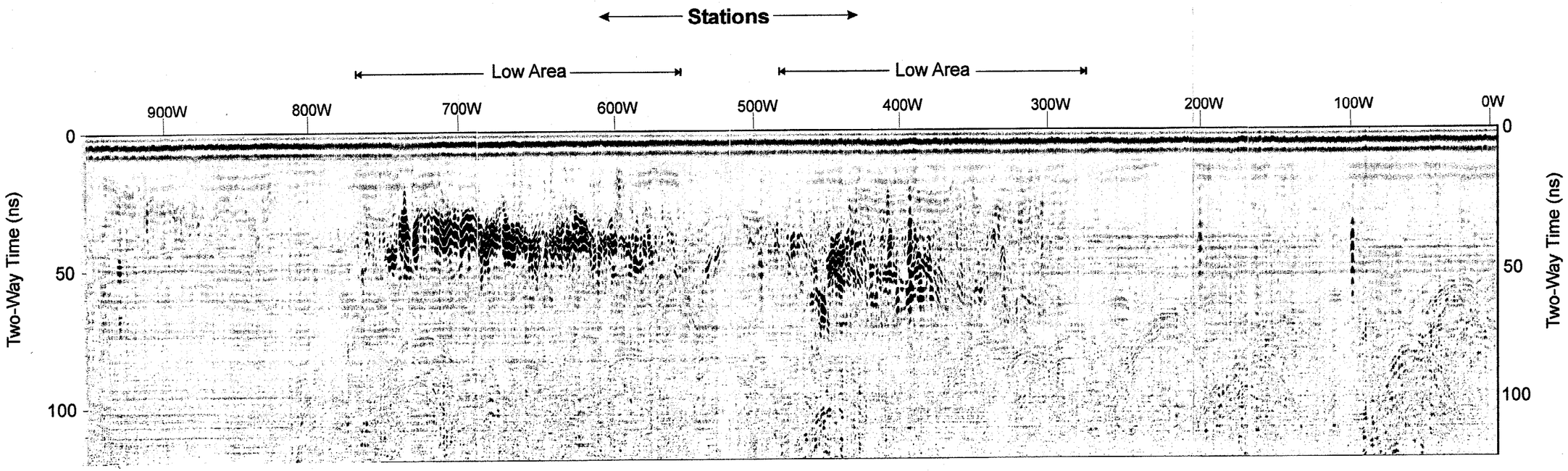
Keller, G. V. and F.C. Frischknecht, 1966, Electrical Methods in Geophysical Prospecting, International Series in Electromagnetic Waves, Volume 10, Pergamon Press, Oxford, England.

Ulriksen, C.P.F., 1982, Application of Impulse Radar to Civil Engineering, Department of Engineering Geology, Lund University of Technology, Sweden.

West **East**



BLACKHAWK GeoServices
Southeast Region

SAIC
Oak Ridge, Tennessee

Figure No.
1

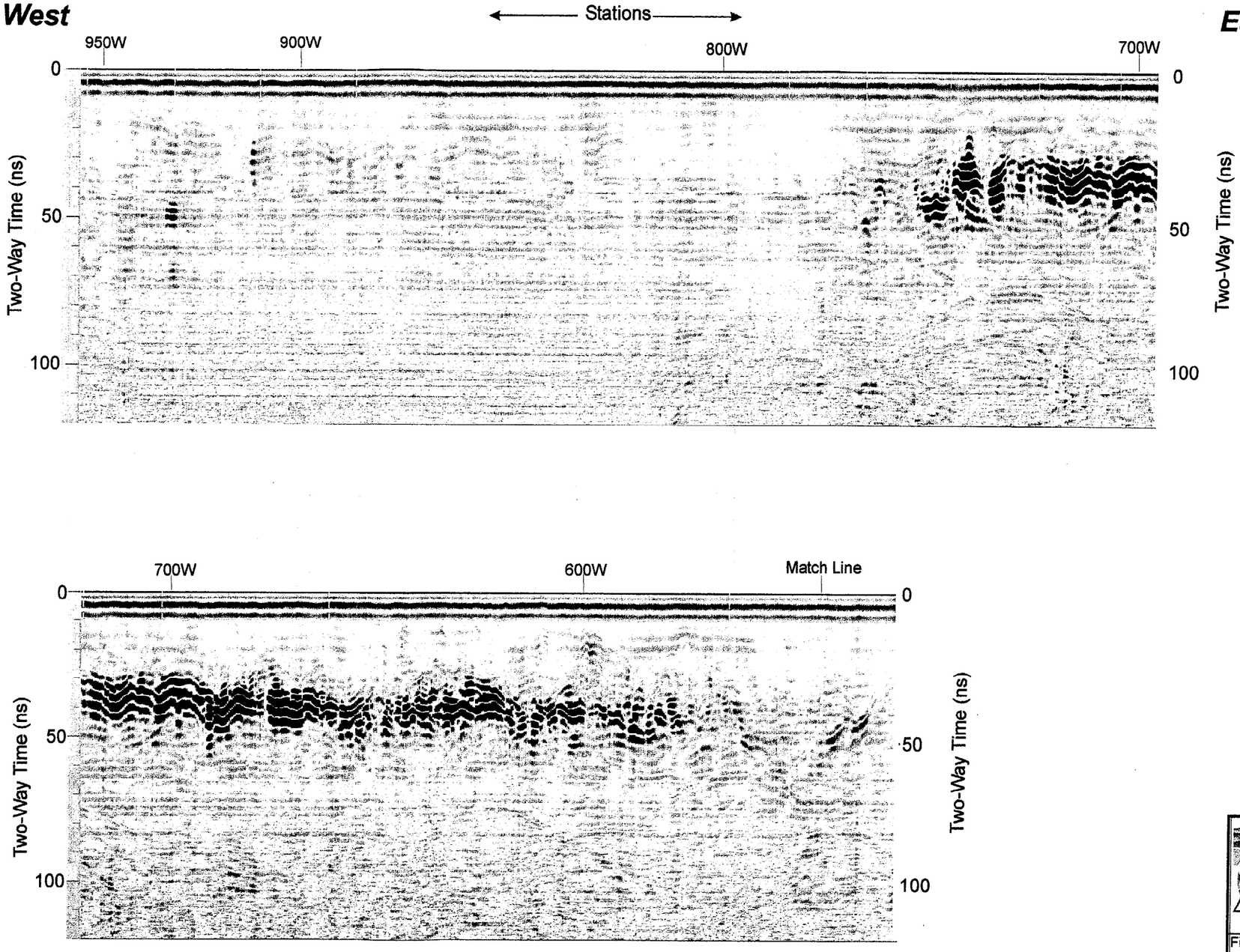
Project No.
2901SAI203

File No.
2901sai203/fig1

Date:
May, 2002

Line 30S, Field File
GPR Profile Data (950W - 0W)
200-MHz Antenna

Barnes Creek Site



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SAIC
Oak Ridge, Tennessee

Figure No.
2A

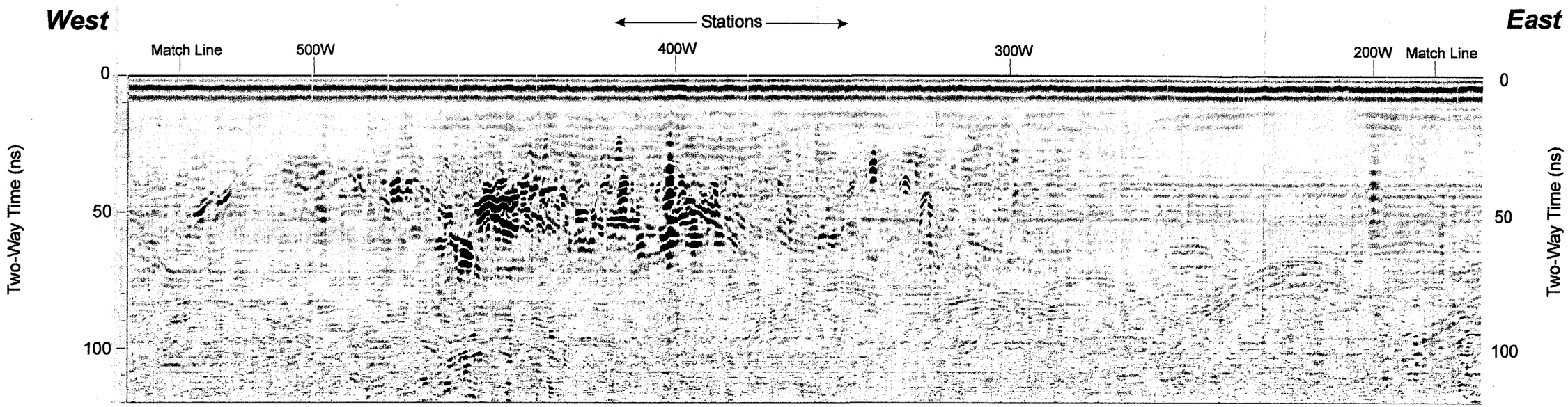
Project No.
2901SAI203

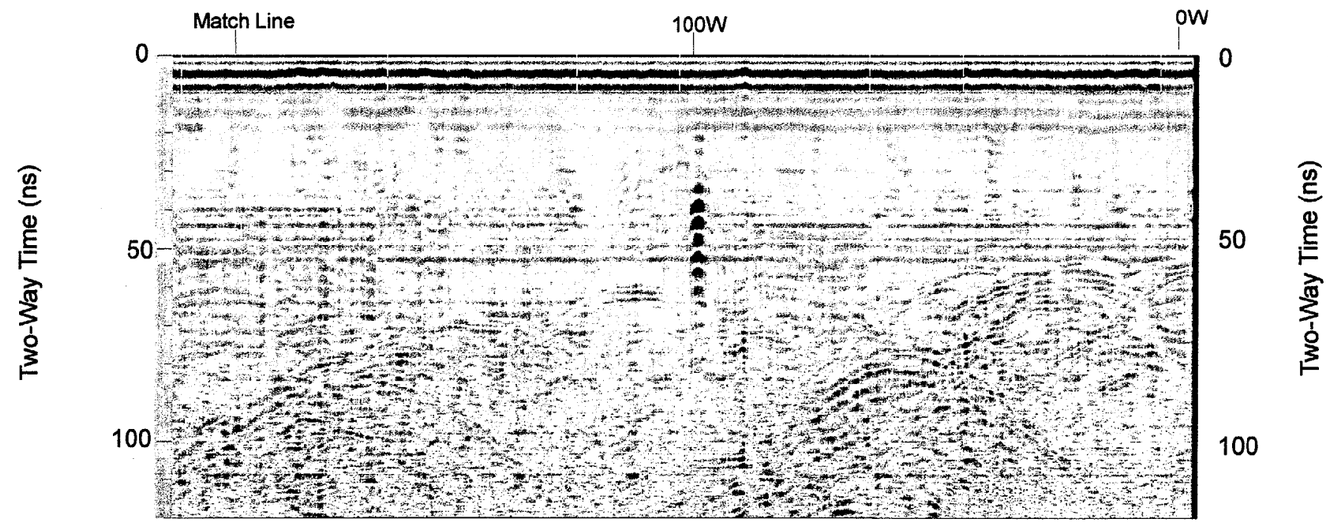
File No.
2901sai203/fig2A

Date:
May, 2002

Line 30S, Field File
GPR Profile Data (950W - 550W)
200-MHz Antenna

Barnes Creek Site





BLACKHAWK GeoServices
Southeast Region

SAIC
Oak Ridge, Tennessee

Figure No.
2B

Project No.
2901SAI203

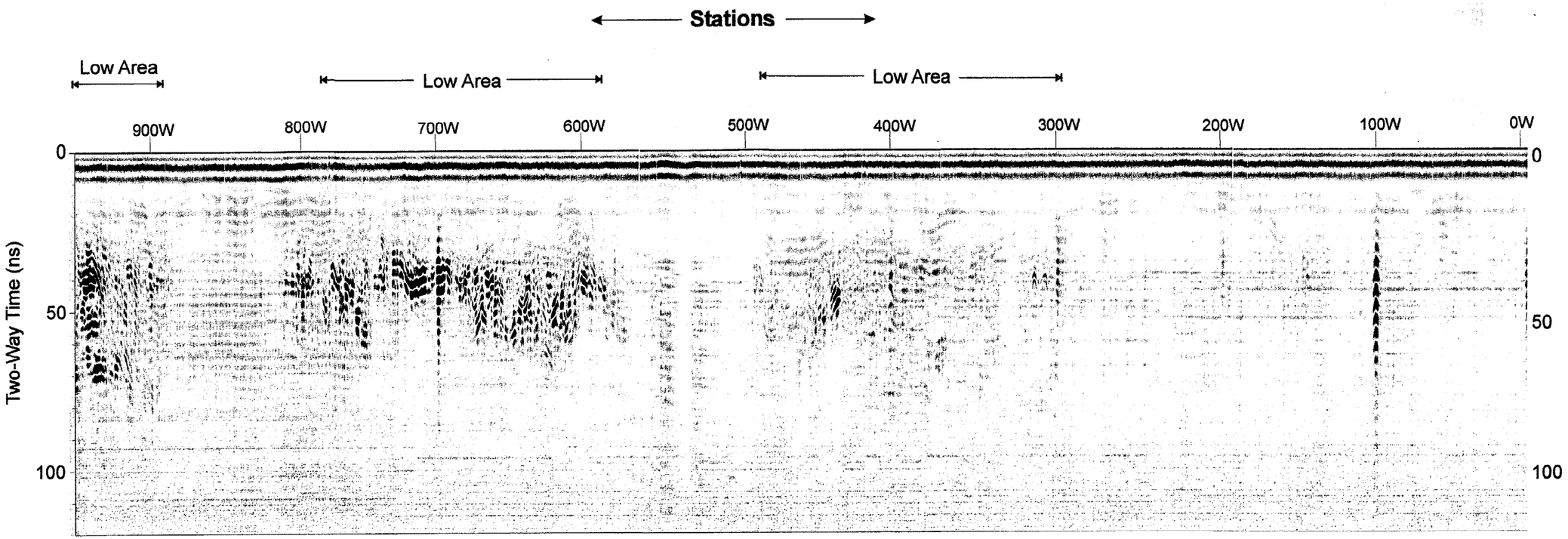
File No.
2901sai203/fig2B

Date:
May, 2002

Line 30S, Field File
GPR Profile Data (550W - 0W)
200-MHz Antenna

Barnes Creek Site

West **East**



BLACKHAWK GeoServices Southeast Region

SAIC
Oak Ridge, Tennessee

Figure No.
3

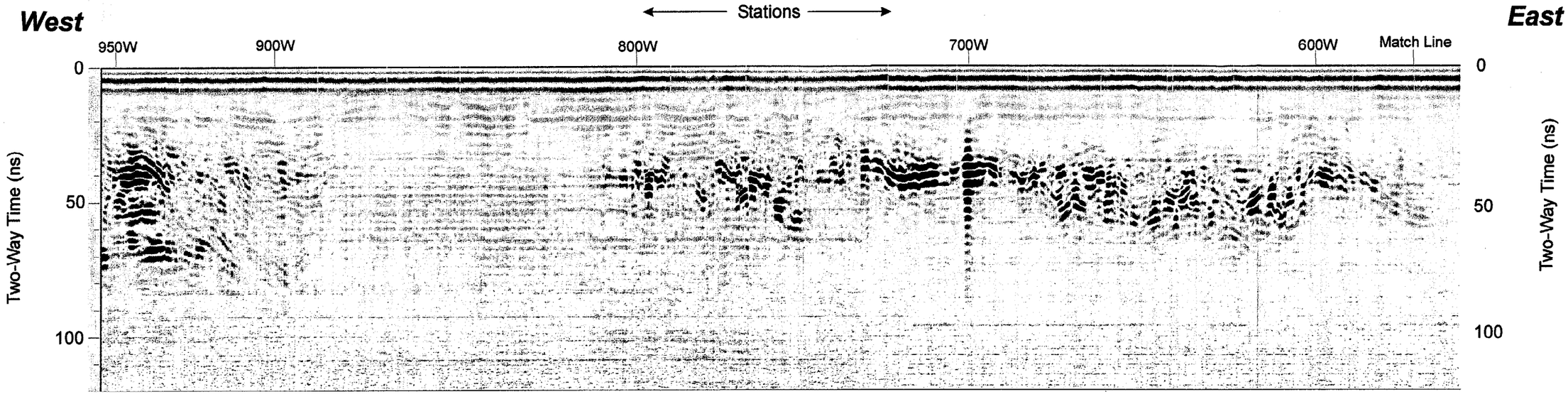
Project No.
2901SAI203

File No.
2901sai203/fig3

Date:
May, 2002

Line 80S, Field File
GPR Profile Data (950W - 0W)
200-MHz Antenna

Barnes Creek Site



BLACKHAWK GeoServices
Southeast Region

SAIC
Oak Ridge, Tennessee

Figure No.
4A

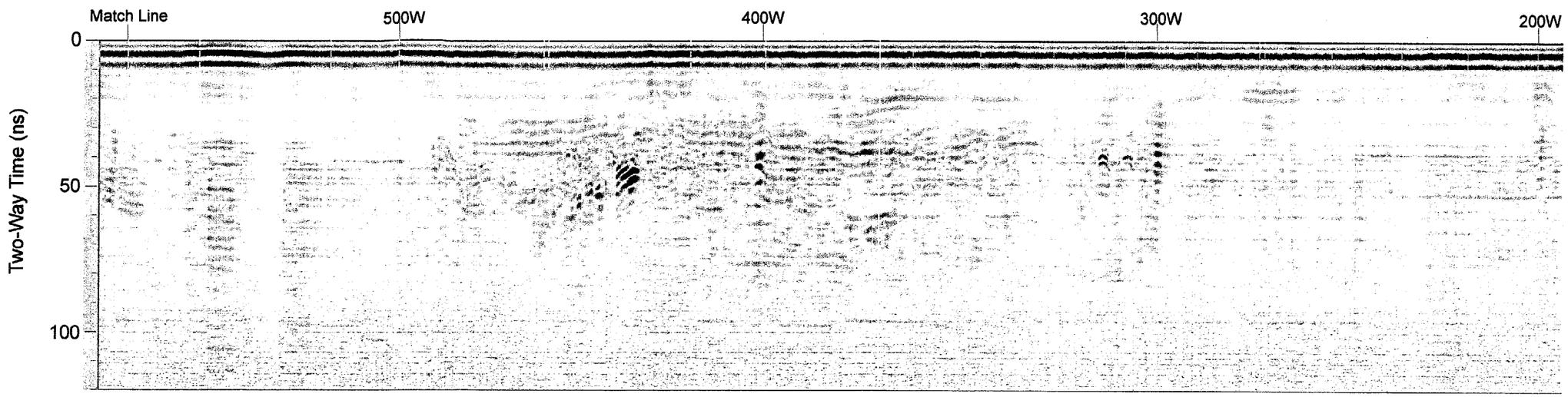
Project No.
2901SAI203

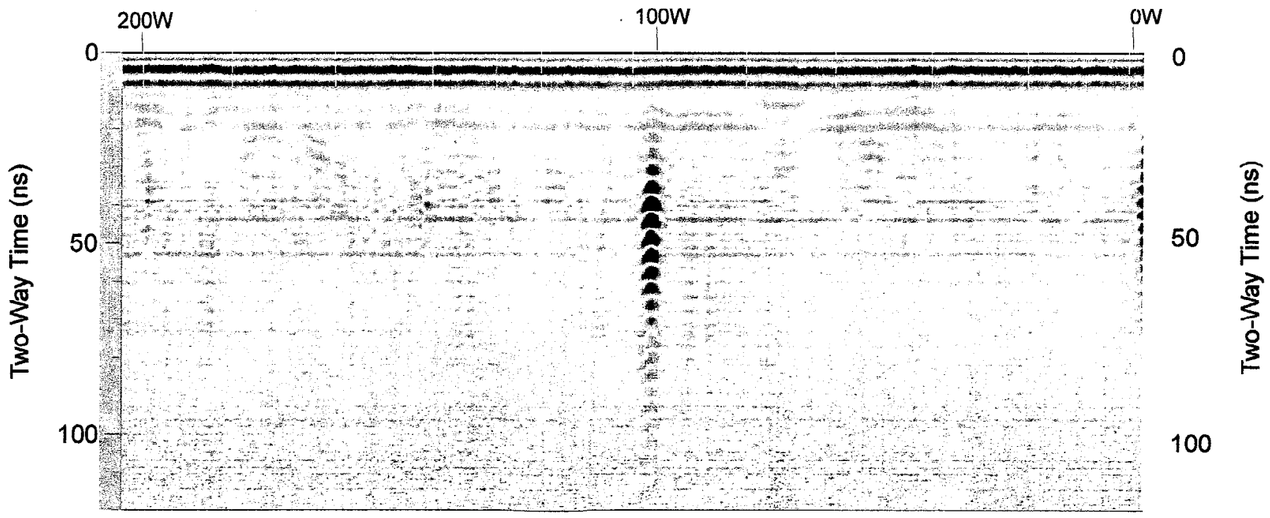
File No.
2901sai203/fig4A

Date:
May, 2002

Line 80S, Field File
GPR Profile Data (950W - 550W)
200-MHz Antenna

Barnes Creek Site





BLACKHAWK GeoServices
Southeast Region

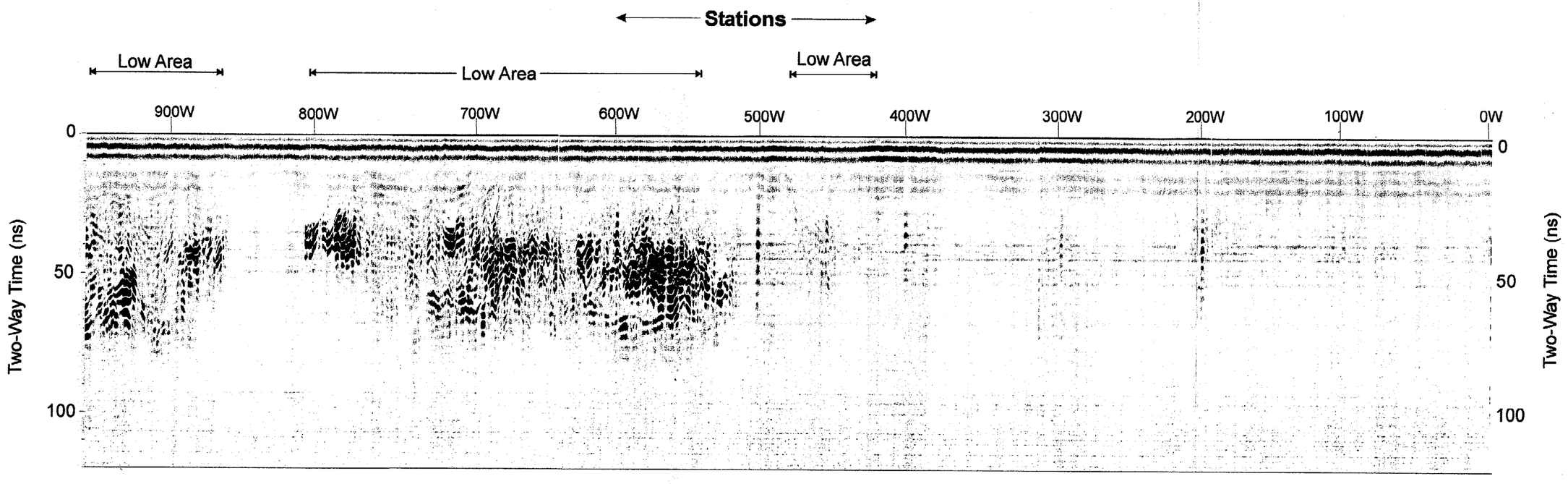
SAIC
Oak Ridge, Tennessee

Figure No.	4B
Project No.	2901SAI203
File No.	*2901sai203/fig4B*
Date:	May, 2002

Line 80S, Field File
GPR Profile Data (550W - 0W)
200-MHz Antenna

Barnes Creek Site

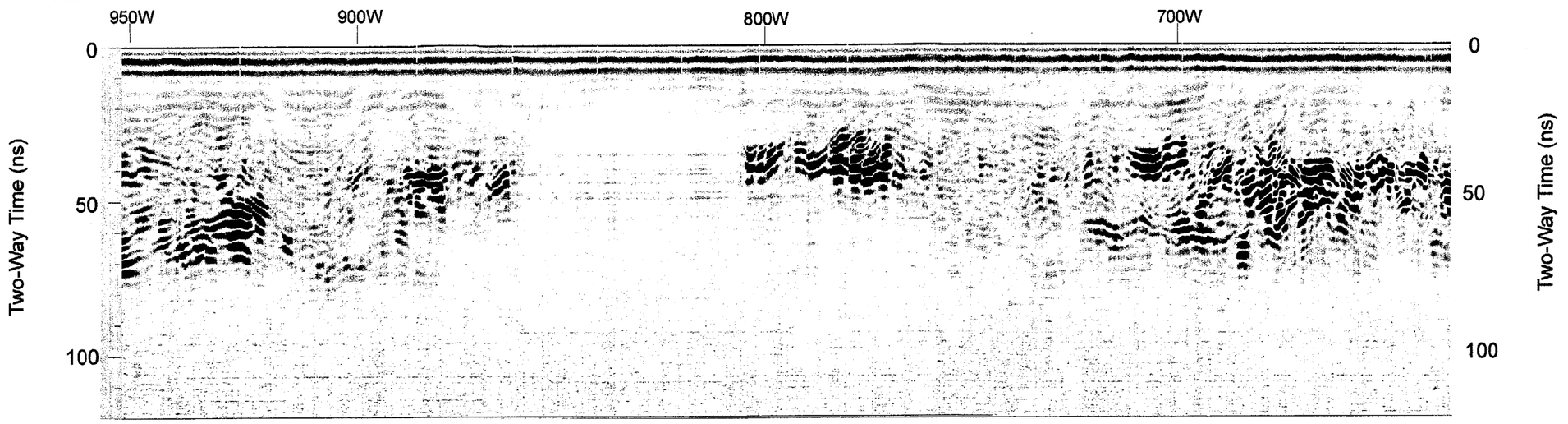
West **East**

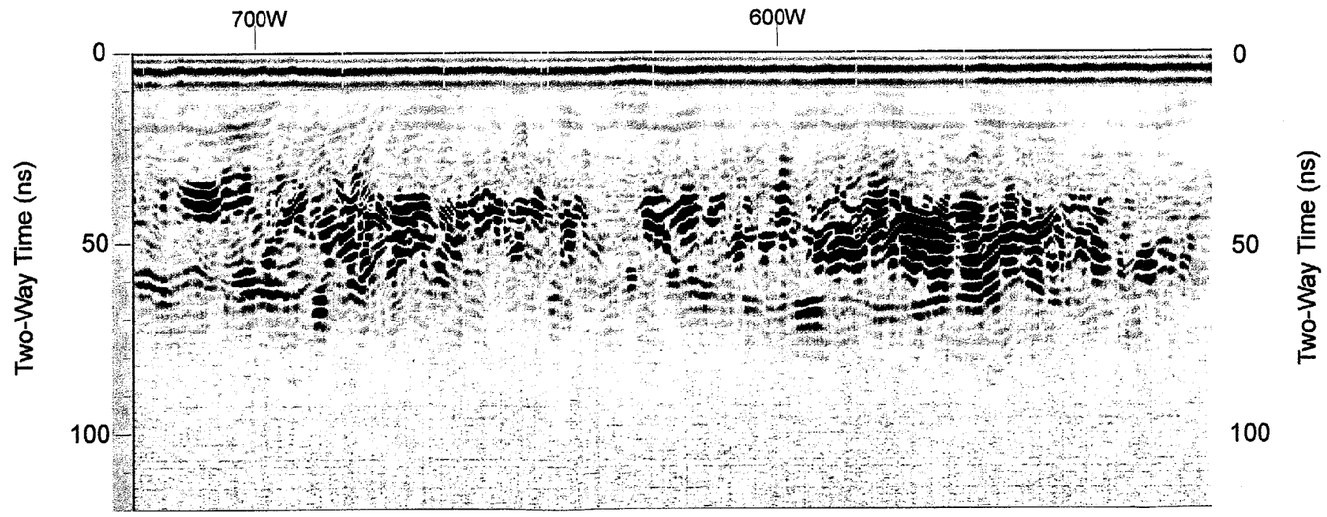


BLACKHAWK GeoServices
Southeast Region

SAIC
Oak Ridge, Tennessee

Figure No. 5	**Line 130S, Field File** **GPR Profile Data (950W - 0W)** **200-MHz Antenna**
Project No. 2901SAI203	
File No. *2901sai203/fig5*	Barnes Creek Site
Date: May, 2002	





BLACKHAWK GeoServices
Southeast Region

SAIC
Oak Ridge, Tennessee

Figure No.
6A

Project No.
2901SAI203

File No.
2901sai203/fig6A

Date:
May, 2002

Line 130S, Field File
GPR Profile Data (950W - 550W)
200-MHz Antenna

Barnes Creek Site

FIGURES NOT INCLUDED IN D0

ATTACHMENT B-III

DPT SURVEY RESULTS: DRILLING LOGS

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LITHOLOGIC LOG	BORING/WELL NO: BC460	PAGE 1 of 2
Site: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 14:40 on 02-19-02	Drill End (time/date): 15:43 on 02-19-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 32 ft
Logged By: R. Gelinas	Coordinates: 460 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
0		01	3.5	NA	--	--	Topsoil with grass and roots		
							Silt (ML), medium to dark brown, moist to wet		Reworked loess ?
							Grades to		Trace very fine Sand Trace coarse (2-3 mm) Sand Some iron and manganese staining
							Brownish gray and gray		Loess, possibly reworked ?
							Silt (ML) as above		
5		02	3.0	NA	--	--	Variable Silty Sand (SM), Clayey Sand (SC), and Lean Clay (CL), medium gray, yellowish gray, and black, moist		Manganese and iron staining heavy in zones
							Interbedded Clayey Sand (SC) and Silty Sand (SM), dark yellowish brown and brown, moist		Zones of Gravel
10		03	2.6	NA	--	--	Poorly Graded Gravel with Clay and Sand (GP-GC), yellowish brown and orangish brown, moist to nearly dray at base		Maximum Gravel diameter > 1.5 inches Iron and some manganese staining throughout
		04	2.8	NA	--	--	Poorly Graded Gravel with Clay and Sand (GP-GC) as above		
15							Clayey Sand with Gravel (SC), dark yellowish brown, moist		Generally fine Sand with some coarser grains Maximum Gravel diameter up to 1 inch
		05	2.0	NA	--	--	Well Graded Sand with Clay and Gravel (SW-SC), dark yellowish brown, moist		Highly weathered zone Maximum Gravel diameter up to 0.5 inches
							Poorly Graded Gravel with Clay and Sand (GP-GC), medium brownish gray and yellowish gray, moist		Maximum Gravel diameter up to approximately 1.25 inches
20							Probably slough		
		06	3.8	NA	--	--	Clayey Sand with Gravel (SC), dark yellowish brown, wet		Iron stained
							Lean Clay with Sand (CL) to Sandy Lean Clay (CL), variable light gray, yellowish brown, and brownish gray, moist		Trace coarse Sand Some manganese-stained blebs
							Sandy Lean Clay (CL), medium gray and yellowish brown, moist		Fine Sand
25		07	3.0	NA	--	--	Clayey Sand (SC), medium gray and yellowish brown, moist		Few Clay stringers
							Silty Sand (SM), medium yellowish brown and grayish brown		Trace Clay Trace Gravel, maximum diameter up to 0.5 inches
									Unusual horizontal breakage (joints or bedding?) from 25.0-26.3 ft
30		08	2.7	NA	--	--	Sandy Silt (ML) grading to Silty Sand (SM), light greenish gray and yellowish gray, moist		Fine sand

LITHOLOGIC LOG	BORING/WELL NO: BC460	PAGE 2 of 2
Site: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 14:40 on 02-19-02	Drill End (time/date): 15:43 on 02-19-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 32 ft
Logged By: R. Gelinas	Coordinates: 460 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
35		08	--	NA	--	--	Silty Sand (SM) grading (at 30.3 ft) to Silt with Sand and Clay (ML), light greenish gray and yellowish gray, moist		Fine Sand Few pieces of water-rounded Gravel at 30.3-30.7 ft Total Depth = 32.0 ft

Prepared by: Kenneth R. Davis — Kenneth R. Davis — 07-19-02 — Date

Checked by: Michelle R. Blanton — 07-23-02 — Date

Approved by: Bruce J. Haas — 07-29-02 — Date

LITHOLOGIC LOG	BORING/WELL NO: BC510	PAGE 1 of 2
Site: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 10:20 on 02-19-02	Drill End (time/date): 11:30 on 02-19-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 32 ft
Logged By: R. Gelinas	Coordinates: 510 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
		01	4.0	NA	--	--	Silt (ML), medium gray and dark yellowish brown, moist		Very little topsoil Loess Trace very fine Sand Small 2-3 mm blebs of black manganese staining Massive
5		02	3.7	NA	--	--	Silt (ML) as above		Sand content increases with depth Trace 2-4 mm, water-rounded grains Trace iron staining Local heavy manganese staining Becomes iron cemented and stained at 6.7-7.2 ft
							Sandy Clay (CL) to Lean Clay with some sand (CL), medium brown and gray, moist		Possibly reworked loess, Fine Sand
							Sandy Clay to Lean Clay (CL) as above		
							Sandy Lean Clay (CL), med gray, brown and black, moist		Very fine Sand Heavy manganese staining
							Gravelly Sand (SP-SC), dark yellowish brown		Fine to medium Sand Heavily weathered, iron stained
10		03	2.9	NA	--	--	Poorly Graded Gravel with Clay and Sand (GP-GC), medium to dark brown and gray, moist		Maximum Gravel diameter up to 1 inch
15		04	3.1	NA	--	--	Poorly Graded Gravel with Clay and Sand (GP-GC) as above but colored medium yellowish brown and dark brown		
							Poorly Graded Gravel with Clay and Sand (GP-GC), medium brown to yellowish brown, moist		
							Silty Sand (SM), light to medium brown, wet		Fine Sand
		05	2.4	NA	--	--	Poorly Graded Gravel with Clay and Sand (GP-GC)		
20							Silty Sand (SM), medium grayish brown, wet		Fine to medium Sand Trace fine Gravel
							Silty Sand (SM) as above		
							Poorly Graded Gravel with Clay and Sand (GP-GC), reddish brown and gray, moist		
		06	2.6	NA	--	--	Silt (ML) to Lean Clay with Sand (CL), moist		Very fine Sand Massive, few 2-3 mm, manganese blebs
							Sandy Silt (ML), medium gray, moist		
25							Lean Clay (CL) dark gray, moist		
							Sandy Silt (ML), medium gray, moist		
		07	3.4	NA	--	--	Lean Clay (CL) dark gray, moist		
							Silt with Sand (ML), dark gray, orange brown, medium brown		Fine Sand, amount varies Some Clayey areas Trace fine gravel
							Sandy Lean Clay (CL), gray, brown, and orangish-brown, moist		Trace Gravel With iron staining and trace manganese staining
30		08	2.6	NA	--	--	Interbedded Poorly Graded Gravel with Clay and Sand (GP-GC) with Well Graded Sand with Clay and Gravel (SW-SC), moist		Maximum diameter of Gravel up to 1 inch Some iron staining

LITHOLOGIC LOG	BORING/WELL NO: BC510	PAGE 2 of 2
Site: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 10:20 on 02-19-02	Drill End (time/date): 11:30 on 02-19-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 32 ft
Logged By: R. Gelinas	Coordinates: 510 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
		08	2.6	NA	--	--	Interbedded Poorly Graded Gravel with Clay and Sand (GP-GC) with Well Graded Sand with Clay and Gravel (SW-SC), moist		Maximum diameter of Gravel up to 1 inch Some iron staining
									Total Depth = 32.0 ft
35									

Prepared by: Kenneth R. Davis — Kenneth R. Davis — 07-19-02 — Date

Checked by: Michelle R. Blanton — 07/23/02 — Date

Approved by: Bruce J. Haas — 07/29/02 — Date

LITHOLOGIC LOG	BORING/WELL NO: BC560	PAGE 1 of 2
Facility: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 09:06 on 02-19-02	Drill End (time/date): 10:08 on 02-19-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 32 ft
Logged By: R. Gelinas	Coordinates: 560 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
							Topsoil, few roots		
		01	3.3	NA	--	--	Silt (ML), medium to dark brown, wet		Loess Massive Trace very fine Sand Trace organics Small carbonized wood fragment at 1.9 ft
5		02	3.7	NA	--	--	Silt (ML), brown, yellowish brown, and gray, moist		Massive Trace very fine Sand Some iron and manganese staining
							Poorly Graded Gravel with Clay and Sand (GP-GC), medium yellowish brown moist		Maximum Gravel diameter up to 0.5 inches Iron and manganese staining
							Some portions are Well Graded Sand with Clay and Gravel (SW-SC)		
							Poorly Graded Gravel (GP-GC) with Well Graded Sand (SW-SC) as above		Iron staining heavy in places
10		03	2.5	NA	--	--	Silty Sand (SM), light gray and yellowish brown, moist		Fine Sand
							Poorly Graded Gravel with Clay and Sand (GP-GC), medium brown and yellowish brown, moist		Maximum Gravel diameter up to 0.5 inches Iron and manganese staining
15		04	2.6	NA	--	--	Poorly Graded Gravel with Clay and Sand (GP-GC), medium brown to yellowish brown, moist		Maximum Gravel diameter up to 1.5 inches, water rounded, includes chert and deeply weathered red clasts Some iron and manganese staining
20		05	2.2	NA	--	--	Interbedded Poorly Graded Gravel with Clay and Sand (GP-GC) and Well Graded Sand with Clay and Gravel (SW-SC), medium brown, medium gray, and reddish brown, moist		Maximum Gravel diameter up to 1.5 inches Locally heavy iron staining Trace manganese staining
							Interbedded Poorly Graded Gravel with Clay and Sand (GP-GC) and Well Graded Sand with Clay and Gravel (SW-SC) as above		
		06	2.3	NA	--	--	Lean Clay with Sand (CL) grading to Clayey Sand (SC), variably colored medium gray, medium brown, and yellowish brown, moist		Fine Sand Horizontal bedding
25							Silty Sand (SM), medium brown, wet		Fine to medium Sand
							Poorly Graded Gravel with Clay and Sand (GP-GC), medium brown and gray, wet		Maximum Gravel diameter up to 0.75 inches Iron and manganese stained
		07	3.3	NA	--	--	Silt (ML) to Elastic SIlt with Sand (MH), medium gray and brownish gray, moist		Very fine Sand Locally heavy manganese staining Somewhat massive (unstructured) , few thin clay laminations
							Silty Sand (SM) medium brown, wet		Fine to medium Sand
30		08	3.7	NA	--	--	Lean Clay (CL) to Sandy Lean Clay (CL), medium brownish gray to yellowish gray, moist		Very fine Sand Trace fine Gravel Lean Clay (CL) rip up clasts ?, dark gray, at 28.6-29.1 ft

LITHOLOGIC LOG	BORING/WELL NO: BC560	PAGE 2 of 2
Facility: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 09:06 on 02-19-02	Drill End (time/date): 10:08 on 02-19-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 32 ft
Logged By: R. Gelinas	Coordinates: 560 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
		08	3.7	NA	--	--	Lean Clay (CL) to Sandy Lean Clay (CL), medium brownish gray to yellowish gray, moist		Very fine Sand Trace fine Gravel Lean Clay (CL) rip up clast?, dark gray, at 30.4-31.0 ft, with very sharp vertical boundary
									Total Depth = 32.0 ft
35									

Prepared by: Kenneth R. Davis — Kenneth R. Davis — 07-19-02 — Date

Checked by: Michelle R. Blanton — Michelle R. Blanton — 07/23/02 — Date

Approved by: Bruce J. Haas — Bruce J. Haas — 07/29/02 — Date

LITHOLOGIC LOG	BORING/WELL NO: BC610	PAGE 1 of 2
Facility: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 13:05 on 02-19-02	Drill End (time/date): 14:20 on 02-19-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 32 ft
Logged By: R. Gelinas	Coordinates: 610 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
							Topsoil		
		01	3.1	NA	--	--	Silt (ML), medium brown, dark brown, and grayish brown, moist		Reworked Loess? (Alluvium) Trace very fine Sand Some iron and manganese staining
5							Silty Sand with Gravel (SM), light brown to dark brown, moist		Fine Sand Portion heavily iron and manganese stained/cemented
		02	3.7	NA	--	--	Sandy Silt (ML), Silt with Sand (ML) and interbeds of some more clayey material, gray, brown, and black, moist		Fine Sand Very heavy manganese staining and lighter iron staining
10		03	2.5	NA	--	--	Well Graded Sand with Clay and Gravel (SW-SC) grading to Poorly Graded Gravel with Clay and Sand (GP-GC), color grades from medium gray at top and orange brown to medium brown to dark brown and black, moist		Maximum diameter of Gravel up to >1 inch Very heavy manganese staining at 9.6-10.1 ft
15		04	2.8	NA	--	--	Poorly Graded Gravel with Clay and Sand (GP-GC), medium orange brown, moist		Maximum diameter of Gravel up to 0.75 inches Some iron staining
		05	3.1	NA	--	--	Poorly Graded Gravel with Clay and Sand (GP-GC), medium yellowish brown grading downward to reddish brown, moist with Silty Sand (SM) layer at 17.8-18.0 ft, medium gray to yellowish gray		Maximum diameter of Gravel up to 0.5 inches Iron staining picks up with depth
20		06	2.5	NA	--	--	Poorly Graded Gravel with Clay and Sand (GP-GC), medium brown to dark reddish brown, moist		Maximum diameter of Gravel up to 1 inch Heavy iron staining, some manganese staining
							Sandy Lean Clay (CL) grading to Lean Clay with trace Sand (CL), medium brown, grayish brown, gray, and yellowish brown, moist		
							Sandy Silt (ML), dark brown, wet		
25		07	3.6	NA	--	--	Lean Clay with Sand (CL) to Sandy Lean Clay (CL), medium yellowish brown, medium brown, and gray,		Few Lean Clay (CL) layers with no Sand Very fine to fine Sand Some manganese and iron staining Horizontal bedding
							Probably slough (Clayey Sand)		
30		08	2.9	NA	--	--	Clayey Sand (SC), moist		Trace fine Gravel Some Clay rip up clasts? Trace iron and manganese staining

LITHOLOGIC LOG	BORING/WELL NO: BC610	PAGE 2 of 2
Facility: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 13:05 on 02-19-02	Drill End (time/date): 14:20 on 02-19-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 32 ft
Logged By: R. Gelinas	Coordinates: 610 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
							Clayey Sand (SC), moist		Trace fine Gravel
		08	--	NA	--	--	Well Graded Sand with Clay and Gravel (SW-SC), medium gray at top grading to dark yellowish brown at bottom, moist		Iron and manganese staining
									Total Depth = 32.0 ft
35									

Prepared by: Kenneth R. Davis — Kenneth R. Davis — 07-19-02 — Date

Checked by: Michelle R. Blanton — 07/23/02 — Date

Approved by: Bruce J. Haas — 07/29/02 — Date

LITHOLOGIC LOG	BORING/WELL NO: BC700	PAGE 1 of 2
Facility: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 08:59 on 02-21-02	Drill End (time/date): 11:20 on 02-21-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth:56 ft
Logged By: R. Gelinas	Coordinates: 700 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
							Topsoil with roots		
							Silt (ML), medium brown, very soft, wet		
		01	3.5	NA	--	--	Silt (ML), medium brown grading to orangish brown, yellow brown, and light brownish gray, wet grading to moist		Loess Trace fine Sand and rare coarse Sand Iron and manganese staining
5		02	3.8	NA	--	--	Silt (ML), medium yellowish gray and grayish brown, moist		Loess, possibly reworked? Trace fine Sand and rare 2 mm Sand Iron and manganese staining and few, thin, cemented zones
							Well Graded Sand with Clay and Gravel (SW-SC), medium brown, dark yellowish brown, and gray, moist		Heavily weathered at 7.4 ft Maximum diameter of Gravel up to 0.2-0.4 inches
10		03	2.9	NA	--	--	Interbedded Poorly Graded Gravel with Clay and Sand (GP-GC) and Well Graded Sand with Clay and Gravel (SW-SC), medium brown, yellowish brown, and yellowish gray, moist		Light iron and manganese staining
		04	2.5	NA	--	--	Interbedded Poorly Graded Gravel with Clay and Sand (GP-GC) and Well Graded Sand with Clay and gravel (SW-SC) as above		
15							Interbedded Clayey Sand (SC), Sandy Lean Clay (CL), and Silty Sand (SM), medium gray, yellowish brown, and grayish brown, moist		Trace Gravel, 0.1 inch diameter, rounded Portions heavily manganese stained Some iron staining Beds appear to dip at high angle (~60°)
		05	3.4	NA	--	--	Lean Clay (CL), with some Silt (ML) interbeds, medium gray and yellowish gray, moist		Trace fine Sand Appears to be somewhat layered to massive
20							Silty Sand (SM), yellowish gray and yellowish brown grading to light gray, moist		Fine Sand, trace mica Trace Gravel with maximum diameter up to 0.25 inches Heavy manganese staining along some laminations and around gravel Beds appear to be nearly horizontal
		06	2.1	NA	--	--	Silty Sand (SM) as above		
							Well Graded Sand with Clay and Gravel (SW-SC), to Poorly Graded Gravel with Clay and Sand (GP-GC), medium gray to yellowish gray, wet at top to moist		Very heavy iron staining at 20.7-21.2 ft
							Sandy Silt (ML), medium gray, moist		Trace coarse Sand and fine Gravel
25		07	2.2	NA	--	--	Silty Sand with Gravel (SM), light gray, wet		
							Interbedded Poorly Graded Gravel with Clay and Sand (GP-GC) and Well Graded Sand with Clay and gravel (SW-SC), yellowish brown, yellowish gray, and light gray, moist		Maximum diameter of gravel up to 0.5 inches
30		08	3.7	NA	--	--	Interbedded Sandy Silt (ML) and Silty Sand (SM), light to medium gray, yellowish gray and yellowish brown, moist		Trace Clay Light iron staining along some beds Bedding appears to dip approximately 30°

LITHOLOGIC LOG	BORING/WELL NO: BC700	PAGE 2 of 2
Facility: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 08:59 on 02-21-02	Drill End (time/date): 11:20 on 02-21-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth:56 ft
Logged By: R. Gelinas	Coordinates: 700 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/ SAFETY VOC	HEALTH/ SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
		08	3.7	NA	--	--	Interbedded Sandy Silt (ML) and Silty Sand (SM), light to medium gray, yellowish gray and yellowish brown, moist		Trace Clay Light iron staining along some beds Bedding appears to dip approximately 30°
		09	3.2	NA	--	--	Interbedded Sandy Silt (ML) and Silty Sand (SM) as above		
							Poorly Graded Sand with Silt and Gravel (SP-SM), light gray, wet		Fine Gravel
35							Interbedded Silty Sand (SM) and Clayey Sand (SC), medium yellowish gray and grayish brown, wet		Heavily iron stained and potential contact at 34.1 ft Becomes finer grained at 35.0 ft Horizontal bedding at 35.0 ft
		10	3.4	NA	--	--	Interbedded Silty Sand (SM) and Clayey Sand (SC) as above but moist		
							Poorly Graded Sand with Clay and Gravel (SP-SC) with some Silty Sand (SC) and Gravelly Sand (SP) interbeds, medium yellowish brown and yellowish gray, wet		Maximum diameter of Gravel up to 0.75 inches "Soupy" consistency at 37.0-37.6 ft
40							Clayey Sand with Gravel (SC), medium yellowish brown, moist		Maximum diameter of Gravel up to 0.25 inches
		11	3.6	NA	--	--	Lean Clay (CL), medium to dark gray, moist		Trace very fine Sand
45		12	3.5	NA	--	--	Lean Clay (CL) with laminations of Elastic Silt (MH), dark gray, moist		Trace very fine Sand in some layers Bedding at high angle (>60°)
50		13	3.9	NA	--	--	Lean Clay (CL) with some laminations of Silt (ML), medium gray and dark yellowish gray		Trace very fine Sand Some iron staining along bedding Bedding appears to be nearly vertical
		14	3.8	NA	--	--	Clayey Sand (SC) grading to Silty Sand (SM), yellowish brown, grayish brown, and reddish brown, wet		Several rip up clasts, light gray
55							Interlaminated/interbedded Lean Clay (CL) and Silt (ML), gray, yellowish gray and yellowish brown, moist		Trace fine Sand Near vertical bedding
							Well Graded Sand with Clay and Gravel (SW-SC), yellowish brown, moist		Total Depth = 56.0 ft

Prepared by: Kenneth R. Davis Kenneth R. Davis Date 07-19-02

Checked by: Michelle R. Blanton MRB Date 07/23/02

Approved by: Bruce J. Haas Date 07/29/02

LITHOLOGIC LOG	BORING/WELL NO: BC736	PAGE 1 of 3
Site: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 08:51 on 02-22-02	Drill End (time/date): 14:05 on 02-22-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 63.5 ft
Logged By: R. Gelinas	Coordinates: 736 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
		01	3.4	NA	--	--	Topsoil Silt (ML), mottled medium grayish brown, yellowish brown, and brown, wet (moist 2.3-2.8 ft)		Loess Trace fine Sand - Sand content higher at 1.4-2.2 ft, becoming a Silt with Sand, very soft Iron and manganese staining
5		02	3.9	NA	--	--	Silt (ML), portions with Sand to Sandy, mottled medium gray, yellowish gray, and brown, moist		Generally fine Sand, trace coarse Sand Trace fine Gravel, water rounded, with maximum diameter <0.25 inches Iron and manganese staining throughout
10		03	3.0	NA	--	--	Silt (ML) as above Well Graded Sand with Clay and Gravel (SW-SC), dark yellowish brown, orange brown, and grayish brown, moist Interbedded Silt (ML) and Sandy Silt (ML), yellowish brown, yellowish gray, and gray, moist		Iron staining Thin to indistinct beds Portions of Sandy Silt are Clayey Trace coarse Sand
15		04	2.6	NA	--	--	Interbedded Silt (ML) and Sandy Silt (ML) as above Poorly Graded Sand with Clay and Gravel (SP-SC) with some beds of Well Graded Sand with Clay and Gravel (SW-SC) and Silty Sand (SM), yellowish gray, gray, and yellowish brown, moist		Fine Sand Maximum diameter of Gravel up to 0.75 inches
20		05	3.4	NA	--	--	Gravelly Lean Clay (CL), brownish gray, moist Poorly Graded Gravel with Sand and Clay (GP-GC), yellowish brown and grayish brown, moist Gravelly Lean Clay (CL), gray and brownish gray, moist Poorly Graded Gravel with Clay and Sand (GP-GC) Interbedded Silty Sand (SM) and Sandy Silt (ML), yellowish brown and yellowish gray, moist		
		06	2.2	NA	--	--	Poorly Graded Gravel with Clay and Sand (GP-GC), medium grayish brown, moist Silty Sand (SC), yellowish to reddish brn, moist Silty Sand (SM), medium yellowish brown and orange brown, moist Silty Sand (SM), moist Silty Sand (SM) as at 21.2-21.9 ft		Maximum diameter of Gravel up to 1 inch Fine to coarse Sand, trace fine Gravel Horizontal bedding Fine Sand, trace coarse Sand Thinly bedded to massive Fine Sand Organic sample collected from 21.8-22.1 ft, completely black within sample interval (organics or manganese staining), no woody material - all finely disseminated
25		07	3.7	NA	--	--	Interlaminated Lean Clay (CL), Silt (ML), and Silty Sand (SM), medium gray, yellowish gray, and yellowish brown, moist		Very fine Sand Very distinctive, almost "varve-like" appearance Iron staining along bedding
30		08	3.7	NA	--	--	Intebedded/Interlaminated Silt (ML) with some Lean Clay (CL), medium gray with some yellowish brown ,moist		Trace very fine Sand, trace mica Iron staining along some beds

LITHOLOGIC LOG	BORING/WELL NO: BC736	PAGE 2 of 3
Site: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 08:51 on 02-22-02	Drill End (time/date): 14:05 on 02-22-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 63.5 ft
Logged By: R. Gelinas	Coordinates: 736 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
		08	3.7	NA	--	--	Interbedded/interlaminated Silt (ML) with some Lean Clay (CL), medium gray with some yellowish brown ,moist		Trace very fine Sand, trace mica Iron staining along some beds
		09	3.7	NA	--	--	Interbedded/interlaminated Silt (ML) with some Lean Clay (CL) as above		Nearly horizontal bedding, "varve like" in appearance
							Silty Sand (SM), yellowish brown, wet		
35							Interbedded/interlaminated Silt (ML) and some Lean Clay (CL), moist		Trace very fine Sand, trace white mica Iron staining along some beds Lamination/bedding typically 0.01-0.4 inches thick
		10	3.7	NA	--	--	Interlaminated Lean Clay (CL) and Silt (ML), medium gray, moist		Trace very fine Sand along some laminations Lamiantions are horizontal and well preserved (no bioturbation)
							Silt (ML), dark yellowish brown and reddish brown, nearly dry		Heavily iron cemented zone Friable/hard fractures
							Lean Clay (CL) and Silt (ML) as at 36.0-37.2 ft		Interlaminated
40		11	3.3	NA	--	--	Interlaminated/interbedded Lean Clay (CL) and Silt (ML), medium gray and yellowish gray, moist		Trace fine Sand
							Silt (ML), dark yellowish brown, moist		Very highly weathered, iron stained
							Interbedded Lean Clay (CL) and Silt (ML), medium gray and dark yellowish gray, moist		Fine Sand along some bedding surfaces Two black 0.1-inch thick organic- or manganese-stained zones in fine Sand at 42.5 and 42.6 ft
							Poorly Graded Sand (SP), light gray, wet		Fine Sand, trace Silt, light iron staining
							Silt (ML), moist		
		12	3.5	NA	--	--	Silt (ML) and Clay (CL), dark yellowish brn and gray, moist		Interbedded
45							Interbedded Silty Sand (SM), Silt (ML), and Clay (CL), gray and grayish yellowish brown, moist to wet		Fine to medium Sand Horizontal bedding
							Clayey Sand (SC), dark yellowish brown, moist		Heavily weathered, iron staining
							Interlaminated/interbedded Silty Sand (SM), Silt (ML), and Lean Clay (CL), medium gray and dark yellowish brown, moist		Highly weathered Silty Sand (SM) at 48.5-48.8 ft
50		13	3.7	NA	--	--	Silt (ML), medium gray with some yellowish gray, becomes dark yellowish brown at 50.9 ft,		Very thinly laminated to thinly bedded Trace fine Sand and mica along some beds 0.1-inch thick black (organic?, manganese?) layer at 50.1 ft 0.25-inch diameter black pebble (iron?) at 51 ft
		14	3.7	NA	--	--	Interlaminated Silt (ML) and Lean Clay (CL), dark yellowish brown, wet		Large shattered rock (almost shale-like) at top of sample, possibly iron-cemented zone Highly weathered
55							Silt (ML) with occasional laminations of Lean Clay (CL) and/or Sandy Silt (ML), light gray, moist		Near horizontal bedding, almost "varve-like" Trace very fine mica
		15	1.7	NA	--	--	Silty Sand (SM), very dark reddish brown, moist		Extremely weathered and iron cemented Portions of upper interval are hard/lithified
60							Interbedded Silty Sand (SM) and Poorly Graded Sand with Silt (SP-SM), grades from dark reddish brown through yellowish brown to tan, wet		Fine to medium Sand

LITHOLOGIC LOG	BORING/WELL NO: BC736	PAGE 3 of 3
Site: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 08:51 on 02-22-02	Drill End (time/date): 14:05 on 02-22-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 63.5 ft
Logged By: R. Gelinas	Coordinates: 736 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
							Silty Sand (SM), very dark red, wet		Fine Sand Extremely weathered, heavy iron staining
							Silty Sand (SM), dark yellowish brown, wet		Horizontal bedding Iron staining
		16	2.2	NA	--	--	Silty Sand (SM) and Sandy Silt (ML), medium yellowish brown, tan, and grayish brown		Very fine Sand
									Total Depth (refusal) = 63.5 ft
65									

Prepared by: Kenneth R. Davis — Kenneth R. Davis — 07-19-02 — Date

Checked by: — Michelle R. Blanton — 07/23/02 — Date

Approved by: — Bruce J. Maas — 07/29/02 — Date

LITHOLOGIC LOG	BORING/WELL NO: BC775	PAGE 1 of 2
Facility: Barnes Creek		Site: Barnes Creek
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 12:46 on 02-21-02	Drill End (time/date): 15:30 on 02-21-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 52 ft
Logged By: R. Gelinas	Coordinates: 775 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/ SAFETY VOC	HEALTH/ SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
							Topsoil		
		01	3.0	NA	--	--	Silt (ML), mottled medium brown, yellowish brown, and grayish brown, wet		Trace fine Sand Very heavy iron/manganese staining at 1.0, 1.7, and 2.3 ft
5		02	3.4	NA	--	--	Silt (ML), mottled, moist		Loess/reworked loess? Trace fine Sand, trace coarse Sand to fine Gravel Iron and manganese staining
							Silt (ML), moist to nearly dry, "crumbly"		Trace fine Sand
							Silt (ML), med brn gray, yellowish gray, and brn, moist		Trace Sand and Clay
10		03	2.6	NA	--	--	Interbeds of Poorly Graded Gravel with Clay and Sand (GP-GC) and Well Graded Sand with Clay and Gravel (SW-SC), dark brown, reddish brown, and gray, moist		Heavy iron-staining/weathered Maximum gravel diameter up to 1.25 inches
		04	2.6	NA	--	--	Interbeds of Poorly Graded Gravel with Clay and Sand (GP-GC) and Well Graded Sand with Clay and Gravel (SW-SC), as above		
15							Finely laminated Lean Clay (CL), Silt (ML) and Silty Fine Sand (SM), light gray, yellow gray and orangish brown, moist		
		05	2.6	NA	--	--	Mixed Clayey Sand (SC) and Silty Sand (SM), dark yellowish brown, yellowish gray, and light gray, moist		Few thin Lean Clay (CL) laminae
							Interbedded Lean Clay (CL), Sandy Silt (ML), and Silty Sand (SM), light gray, yellowish gray and dark yellowish brown, moist		Interbeds <0.25 inches thick Very fine to fine Sand
20		06	3.8	NA	--	--	Lean Clay (CL), Silt (ML), and Silty Sand (SM), medium and light gray, yellowish gray, and brownish gray, moist		Fine Sand Moderate iron staining along some bed surfaces Heavy manganese staining at 20.6 ft Thin laminations and beds <0.5 inches thick Near horizontal bedding
25		07	3.8	NA	--	--	Silt (ML), medium gray and yellowish gray, moist (wet at 29.5-30.0 ft)		Trace fine to very fine Sand Finely laminated, some laminations Clayey Iron staining along some lamination surfaces Near horizontal bedding
30		08	3.6	NA	--	--	Silt (ML) as above		

LITHOLOGIC LOG	BORING/WELL NO: BC775	PAGE 2 of 2
Facility: Barnes Creek		Site: Site 3A
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 12:46 on 02-21-02	Drill End (time/date): 15:30 on 02-21-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 52 ft
Logged By: R. Gelinas	Coordinates: 775 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
		08	3.6	NA	--	--	Silt (ML), medium gray to yellowish gray, moist		Trace fine to very fine Sand Finely laminated, some laminations Clayey Iron staining along some lamination surfaces Near horizontal bedding
35		09	3.6	NA	--	--	Interlaminated /interbedded Silt (ML) and Lean clay (CL), light to medium gray and yellowish brown, moist		Trace very fine Sand Thin interlaminations and beds (<0.5 inches thick) Some laminations have very fine Sand partings iron staining along some laminations Hole is caving to about 35.0 ft
40		10	3.3	NA	--	--	Interbedded Silt (ML), Lean Clay (CL), and Silty Sand (SM) to Poorly Graded Sand with Silt (SP-SM), light gray, medium gray, yellowish gray, and yellowish brown, moist to wet		Fine to medium sand with iron staining Sand content increases downward Bedding <1 inch thick
		11	2.2	NA	--	--	Silty Sand (SM), red, grayish brown, yellowish-brown, wet Interlaminated Silt (ML) Lean Clay (CL) and Silty Sand (SM), yellowish gray, gray, and red, moist Silty Sand (SM), medium yellow to red at base, moist		Thinly bedded, zones with iron staining Very fine Sand Very fine sand
45		12	2.8	NA	--	--	Silty Sand (SM), medium yellowish brown, reddish brown, and red, wet		Fine to very fine Sand Some thin Sandy Silt (ML) layers Somewhat massive to poorly stratified (bedded)
50		13	0.0	NA	--	--			NOTE: Hammered sampler to 48-52 ft interval. 1st 6-8 inches was hard, then standard rate of advancement. Started to pull sample with slow feed and rods pulled out of threads at 1st 5 ft stick above sampler. Left sampler (4 ft long) and one 5 ft stick of pipe in ground. Driller elected to not try and fish out sampler and pipe due to hole caving at 35'. Grouted in place. Refusal at 52 ft

Prepared by: Kenneth R. Davis — Kenneth R. Davis — 07-19-02 — Date

Checked by: Michelle R. Blanton — Michelle R. Blanton — 07/23/02 — Date

Approved by: Bruce J. Haas — Bruce J. Haas — 07/29/02 — Date

LITHOLOGIC LOG	BORING/WELL NO: BC800	PAGE 1 of 2
Facility: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 14:15 on 02-22-02	Drill End (time/date): 15:30 on 02-22-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 32 ft
Logged By: R. Gelinas	Coordinates: 800 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/ SAFETY VOC	HEALTH/ SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
		01	2.9	NA	--	--	Silt (ML), dark brown and dark yellowish-grayish brown, very soft, wet		Reworked loess Some layers trace Sand Heavy iron and manganese staining/cement at 1.3 ft
5		02	2.9	NA	--	--	Silt (ML), gray, grayish brown, moist		Loess Trace fine Sand in some layers
		03	3.4	NA	--	--	Silt (ML) as above Silt with Gravel (ML), medium to dark gray, yellowish brown, and grayish brown, moist Poorly Graded Gravel with Clay and Sand (GP-GC), dark grayish brown, moist		Reworked Loess Trace Sand Some portions Clayey Maximum diameter of Gravel up to 1inch Iron stained Iron-Stained
10									
15		04	2.3	NA	--	--	Poorly Graded Gravel (GP-GC) as above Thinly Laminated Clayey Sand (SC) and Sandy Clay (CL), medium to dark gray and yellowish brown, moist Silty Sand with Gravel (SM), yellowish brown, gray, tan, moist Poorly Graded Gravel with Silt and Sand (GP-GM), yellowish gray to grayish brown, moist		Trace fine Gravel, 0.2 inches in diameter Maximum diameter of Gravel up to 0.75 inches; Some portions are Gravel
20		05	2.4	NA	--	--	Silty Sand (SM) and Clayey Sand (SC), medium gray, yellowish gray, and tan, moist Fat Clay (CH), dark reddish brown, moist Interlaminated/interbedded Lean Clay (CL), Silt (ML), and Silty Sand (SM), light gray, medium gray, tan, white and yellowish brown, moist		Very fine Sand, poorly graded fine Sand (SC) stringers at 18.2 ft and 18.4 ft Almost "varve-like" horizontal bedding
		06	3.3	NA	--	--	Interlaminated/interbedded Lean Clay (CL), Silt (ML), and Silty Sand (SM), medium yellowish brown, moist		Heavily iron-stained sandy portions Almost "varve-like" bedding
25		07	3.7	NA	--	--	Silty Sand (SM), medium yellowish brown, wet Finely laminated Silt (ML) gray and yellowish brown, moist Silty Sand (SM), dark yellowish brown, wet Very thinly laminated Silt (ML), light to medium gray, moist		Medium Sand Few Lean Clay (CL) layers Medium Sand Few Lean Clay (CL) and very fine Sandy Silt (ML) interlaminations Silt lamination are 0.1 to 0.3 inches thick Few iron stained laminations
30		08	3.8	NA	--	--	Finely laminated Silt (ML) with some Lean Clay (CL) and Sandy Silt (ML) interlaminations, light to medium gray, moist		Some yellowish brown iron staining Almost "varve like" bedding

LITHOLOGIC LOG	BORING/WELL NO: BC800	PAGE 2 of 2
Facility: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 14:15 on 02-22-02	Drill End (time/date): 15:30 on 02-22-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 32 ft
Logged By: R. Gelinas	Coordinates: 800 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
		08	3.8	NA	--	--	Finely laminated Silt (ML) with some Lean Clay (CL) and Sandy Silt (ML) interlaminations, light to medium gray, moist		Some yellowish brown iron staining Almost "varve like" bedding
35									Total Depth = 32.0 ft

Prepared by: Kenneth R. Davis — Kenneth R. Davis — 07-19-02 — Date

Checked by: MRBlanton — Michelle R. Blanton — 07/23/02 — Date

Approved by: BJHaas — Bruce J. Haas — 07/29/02 — Date

LITHOLOGIC LOG	BORING/WELL NO: BC825	PAGE 1 of 2
Facility: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 13:38 on 02-18-02	Drill End (time/date): 14:48 on 02-18-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 36 ft
Logged By: R. Gelinas	Coordinates: 825 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
							Topsoil		
		01	4.0	NA	--	--	Silt (ML), medium tannish gray, moist		Loess Trace fine sand, Trace roots Fine organics Massive
							Silt (ML) as above but medium brown		Loess Iron and manganese staining at 2.5–2.8 ft
5		02	4.0	NA	--	--	Silt (ML), medium brown with some gray mottles, moist		Trace very fine sand Massive Trace manganese staining
10		03	3.7	NA	--	--	Silt (ML) medium grayish brown, moist		Reworked Loess? Trace very fine sand Few 0.25-inch diameter pieces of Gravel, water rounded Trace manganese staining Massive
							Sandy Gravel with Clay and Sand (GP-GC), moist		Iron and manganese staining/cementation
		04	2.4	NA	--	--	Sandy Gravel with Clay and Sand (GP-GC) as above		
15							Sandy Clay (CL), mottled medium brown, gray and orange, moist		Gravel towards bottom (water rounded) Light gray band at 13.6 – 13.7 ft Iron and manganese staining throughout
		05	3.1	NA	--	--	Clayey Sand (SC), medium brown to grayish brown, moist		Fine to medium Sand, trace coarse Sand and fine Gravel Iron and manganese staining
							Clayey Sand (SC) grading to Silty Sand (SM), medium gray to brownish gray, moist		Gravel lens, 0.5-inch diameter, at 17.5–17.6 ft
20							Poorly Graded Gravel with Clay and Sand (GP-GC), medium brown, moist		
		06	3.0	NA	--	--	Poorly Graded Gravel with Clay and Sand (GP-GC), medium to dark brown, moist		Maximum diameter of Gravel up to 1 inch, water rounded Iron and manganese staining
25		07	2.9	NA	--	--	Clayey Sand (SC) and Sandy Clay (CL), variably colored – clay mostly medium gray with orange-brown laminations and sand mostly medium brown to tan, wet		Fine to medium Sand Few Silty Sand interbeds Horizontal bedding
							Silty Sand (SM), light grayish brown, wet		Fine to medium Sand
30		08	3.7	NA	--	--	Interlaminated Clayey Sand (SC) and Sandy Clay (CL), alternating medium gray and brown, wet		Fine Sand

LITHOLOGIC LOG	BORING/WELL NO: BC825	PAGE 2 of 2
Facility: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 13:38 on 02-18-02	Drill End (time/date): 14:48 on 02-18-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 36 ft
Logged By: R. Gelinas	Coordinates: 825 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
		08	3.7	NA	–	–	Interlaminated Clayey Sand (SC) and Sandy Clay (CL), alternating medium gray and brown, wet		Fine Sand
35		09	3.4	NA	–	–	Silt (ML) medium gray with brown mottles, wet		Some Clayey interbeds with fine Sand Some minor iron staining.
									Total Depth = 36.0 ft
40									

Prepared by: Kenneth R. Davis — Kenneth R. Davis — 07-19-02 — Date

Checked by: Michelle R. Blanton — Michelle R. Blanton — 07/23/02 — Date

Approved by: Bruce J. Haas — Bruce J. Haas — 07/29/02 — Date

LITHOLOGIC LOG	BORING/WELL NO: BC910	PAGE 1 of 2
Facility: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 15:29 on 02-18-02	Drill End (time/date): 16:55 on 02-18-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 36 ft
Logged By: R. Gelinas	Coordinates: 910 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
		01	3.3	NA	--	--	Silt (ML), medium to dark brown grading to medium grayish brown, moist (wet at 2.8 ft)		Few fine roots and organics in upper 8-10 inches Trace very fine Sand Massive
5		02	2.5	NA	--	--	Silt (ML) as above, wet		Percent Sand increases with depth.
							Poorly Graded Gravel with Clay and Sand (GP-GC), brown, gray, moist		Maximum diameter of Gravel up to 0.5 inches, water rounded Zones of iron and manganese staining
10		03	2.7	NA	--	--	Poorly Graded Gravel (GP-GC) as above		
							Poorly Graded Gravel With Sand (GP), medium brown, dry		Water rounded Gravel with iron staining
							Poorly Graded Gravel with Clay and Sand (GP-GC), variable medium brown, light gray, and tan, moist		
15		04	3.2	NA	--	--	Poorly Graded Gravel with Clay and Sand (GP-GC) as above		
							Silty Sand with trace Clay (SM) grading to Lean Clay with trace Sand (CL), variable color from medium gray to brown, moist		Fine Sand
20		05	3.8	NA	--	--	Lean Clay (CL), medium gray, moist		Some Silt Some fine Sand interbeds Some orange zones of iron-staining Heavy manganese staining at 18.3 ft Laminations deformed in cone-shaped fashion, possibly due to sampler advancement or dipping strata
							Poorly Graded Sand with Silt (SP-SM) to Poorly Graded Sand with trace Silt (SP), light to medium gray, wet		Medium Sand
		06	3.8	NA	--	--	Lean Clay with Gravel and Sand (CL), med gray, wet		Fine Sand Zones with iron staining
							Lean Clay (CL) with some Silt (ML) interbeds, medium gray and brown, wet		Trace fine Sand in some laminations Zones of iron staining Deformed laminations have continued from 16 ft --Dipping at 40°
25		07	3.7	NA	--	--	Lean Clay (CL) with some Silt (ML) interbeds as above		
							Interlaminated Lean Clay (CL) and Sandy Clay (SC), medium gray and orange-brown, wet		Fine Sand Continues dipping at 40°
							Elastic Silt (MH), medium gray, wet		Trace very fine Sand Dipping at 40°
							Interlaminated Lean Clay (CL) and Sandy Clay (SC), medium gray and orange-brown, wet		Very fine Sand
30		08	3.7	NA	--	--	Clayey Sand (SC) to Sandy Clay (CL)		
							Elastic Silt (MH)		Trace fine Sand
							Silty Sand (SM), medium brown to gray, wet		
							Lean Clay (CL)		
							Interbedded Lean Clay (CL) and Clayey Sand (SC)		Fine Sand

LITHOLOGIC LOG	BORING/WELL NO: BC910	PAGE 2 of 2
Facility: Barnes Creek		
Project No: DO 110	Client/Project: USDOE/PGDP Site 3A Seismic Assessment	
Contractor: SAIC	Drill Contractor: Greg In-Situ	Driller: Mike Davis
Drill Start (time/date): 13:38 on 02-18-02	Drill End (time/date): 14:48 on 02-18-02	Borehole Dia: 2 inch
Drill Method/Rig Type: Direct Push with Track Rig D-24 (MacroCore 4-ft Sampler)		Total Depth: 36 ft
Logged By: R. Gelinas	Coordinates: 910 ft west of start point	Protective Level: D

DEPTH (ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (ft)	SPT RESULT 6"-6"-6"-6" (N)	HEALTH/SAFETY VOC	HEALTH/SAFETY RAD	LITHOLOGIC DESCRIPTION	GRAPH LOG	COMMENTS
		08	3.7	NA	--	--	Interbedded Lean Clay (CL) and Clayey Sand (SC), medium gray, brown, and orange, moist to wet		Fine Sand Still dipping ~ 45°
							Silty Sand (SM)		
							Lean Clay (CL), medium gray, moist to wet in sandy zones		Few Sandy Clay (CL) interbeds Sandy zones are orange with iron staining
		09	3.7	NA	--	--	Silty Sand (SM), medium brown and grayish-brown, moist		Fine Sand Few Clay laminations Heavy iron staining and cemented at 32.9-33.2 ft
35							Silt (ML) with some Elastic Silt (MH) interbeds, medium gray with brownish-orange zones, moist to wet		Few 1-inch thick Silty Sand (SM) interbeds, trace mica Dipping > 45°
									Total Depth = 36.0 ft
40									

Prepared by: Kenneth R. Davis — Kenneth R. Davis — 07-19-02 — Date

Checked by: — Michelle R. Blanton — 07/23/02 — Date

Approved by: — Bruce D. Haas — 07/29/02 — Date

ATTACHMENT B-IV

^{14}C AGE DATING LABORATORY ANALYSES

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BETA
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MR. DARDEN HOOD
Director

Mr. Ronald Hatfield
Mr. Christopher Patrick
Deputy Directors

April 29, 2002

INFORMATION ONLY

Ms. Kay Dabney
United States Enrichment Corporation
Paducah Gaseous Diffusion Plant
P.O. Box 1410
Paducah, KY 42001
USA

RE: Radiocarbon Dating Results For Samples CCFRD460-1, CCFRD560-1, CCFRD610-1, CCFRD736-1, CCFRD736-2, CCGTD440L2, CCGTD500L2, CCGTD620L3, CCGTD670L3, CCGTSB03C04, CCGTSB03C36, CCGTSB06C11

Dear Ms. Dabney:

Enclosed are the radiocarbon dating results for 12 samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses went normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice has been sent separately. Our copy is enclosed. Thank you for your prior efforts in arranging payment. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

BETA

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

UNIVERSITY BRANCH
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305/667 5167 FAX: 305/663-0964
E MAIL: beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Ms. Kay Dabney

Report Date: 4/29/02

United States Enrichment Corporation

INFORMATION ONLY

Material Received: 4/12/02

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 166595	1160 +/- 40 BP	-23.0 o/oo	1190 +/- 40 BP
SAMPLE : CCFRD460-1			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (organic sediment): acid washes			
2 SIGMA CALIBRATION : Cal AD 720 to 740 (Cal BP 1230 to 1210) AND Cal AD 760 to 960 (Cal BP 1190 to 990)			
Beta - 166596	9160 +/- 50 BP	-22.6 o/oo	9200 +/- 50 BP
SAMPLE : CCFRD560-1			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (organic sediment): acid washes			
2 SIGMA CALIBRATION : Cal BC 8560 to 8280 (Cal BP 10510 to 10230)			
Beta - 166598	7230 +/- 40 BP	-23.4 o/oo	7260 +/- 40 BP
SAMPLE : CCFRD610-1			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (organic sediment): acid washes			
2 SIGMA CALIBRATION : Cal BC 6220 to 6020 (Cal BP 8160 to 7970)			
Beta - 166599	11130 +/- 60 BP	-22.5 o/oo	11170 +/- 60 BP
SAMPLE : CCFRD736-1			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (organic sediment): acid washes			
2 SIGMA CALIBRATION : Cal BC 11440 to 11290 (Cal BP 13390 to 13240) AND Cal BC 11270 to 11040 (Cal BP 13220 to 12990)			
Beta - 166600	10760 +/- 50 BP	-22.6 o/oo	10800 +/- 50 BP
SAMPLE : CCFRD736-2			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (organic sediment): acid washes			
2 SIGMA CALIBRATION : Cal BC 11040 to 10850 (Cal BP 12990 to 12800) AND Cal BC 10790 to 10690 (Cal BP 12740 to 12640)			

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By international convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

UNIVERSITY BRANCH
4985 S.W. 74 COURT
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E MAIL : beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Ms. Kay Dabney

INFORMATION ONLY

Report Date: 4/29/02

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 166602	13540 +/- 60 BP	-23.3 o/oo	13570 +/- 60 BP
SAMPLE : CCGTD440L2			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (organic sediment): acid washes			
2 SIGMA CALIBRATION : Cal BC 14750 to 14000 (Cal BP 16700 to 15950)			
Beta - 166603	3770 +/- 50 BP	-23.5 o/oo	3790 +/- 50 BP
SAMPLE : CCGTD500L2			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (organic sediment): acid washes			
2 SIGMA CALIBRATION : Cal BC 2400 to 2380 (Cal BP 4350 to 4330) AND Cal BC 2360 to 2120 (Cal BP 4300 to 4060) Cal BC 2100 to 2040 (Cal BP 4050 to 3990)			
Beta - 166604	13850 +/- 60 BP	-22.2 o/oo	13900 +/- 60 BP
SAMPLE : CCGTD620L3			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (organic sediment): acid washes			
2 SIGMA CALIBRATION : Cal BC 15100 to 14340 (Cal BP 17050 to 16300)			
Beta - 166605	15620 +/- 70 BP	-22.2 o/oo	15670 +/- 70 BP
SAMPLE : CCGTD670L3			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (organic sediment): acid washes			
2 SIGMA CALIBRATION : Cal BC 17220 to 16330 (Cal BP 19170 to 18280)			
Beta - 166606	4190 +/- 40 BP	-22.1 o/oo	4240 +/- 40 BP
SAMPLE : CCGTSB03C04			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (organic sediment): acid washes			
2 SIGMA CALIBRATION : Cal BC 2910 to 2860 (Cal BP 4860 to 4810) AND Cal BC 2810 to 2750 (Cal BP 4760 to 4700) Cal BC 2720 to 2700 (Cal BP 4670 to 4650)			

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By international convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calender years. Calibration to calendar years should be calculated using the Conventional C14 age.

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REPORT OF RADIOCARBON DATING ANALYSES

Ms. Kay Dabney

INFORMATION ONLY

Report Date: 4/29/02

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 166607 SAMPLE : CCGTSB03C36 ANALYSIS : AMS-Advance delivery MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal BC 6220 to 6040 (Cal BP 8170 to 7990)	7230 +/- 40 BP	-21.9 o/oo	7280 +/- 40 BP
Beta - 166608 SAMPLE : CCGTSB06C11 ANALYSIS : AMS-Advance delivery MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal BC 5760 to 5650 (Cal BP 7710 to 7600)	6790 +/- 40 BP	-22.8 o/oo	6830 +/- 40 BP

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By international convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

Ms. Kay Dabney

Report Date: 3/14/02

United States Enrichment Corporation

Material Received: 2/28/02

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 165492 SAMPLE : CCFRBS-01 ANALYSIS : AMS-Advance delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 2140 to 1880 (Cal BP 4090 to 3830) Comment: the original sample was too small for a 13C/12C ratio measurement. However, a ratio including both natural and laboratory effects was measured during the 14C detection to derive a Conventional Radiocarbon Age, suitable for applicable calendar calibration.	NA	NA	3630 +/- 50 BP
Beta - 165496 SAMPLE : CCFRBS-06 ANALYSIS : AMS-Advance delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1440 to 1650 (Cal BP 510 to 300)	390 +/- 50 BP	-26.7 o/oo	360 +/- 50 BP
Beta - 165497 SAMPLE : CCFRBS-07 ANALYSIS : AMS-Advance delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 4340 to 4050 (Cal BP 6280 to 6000)	5360 +/- 50 BP	-24.2 o/oo	5370 +/- 50 BP
Beta - 165498 SAMPLE : CCFRBS-08 ANALYSIS : AMS-Advance delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 3950 to 3660 (Cal BP 5900 to 5610)	5010 +/- 50 BP	-25.5 o/oo	5000 +/- 50 BP
Beta - 165499 SAMPLE : CCFRBS-09 ANALYSIS : AMS-Advance delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 5670 to 5510 (Cal BP 7620 to 7460)	6690 +/- 50 BP	-25.6 o/oo	6680 +/- 50 BP

Ms. Kay Dabney

Report Date: 3/14/02

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 165500	5410 +/- 50 BP	-25.0 o/oo	5410 +/- 50 BP
SAMPLE : CCFRBS-10			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal BC 4350 to 4150 (Cal BP 6300 to 6100) AND Cal BC 4120 to 4070 (Cal BP 6070 to 6020)			
Beta - 165501	NA	NA	5700 +/- 50 BP
SAMPLE : CCFRBS-11			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal BC 4680 to 4450 (Cal BP 6640 to 6400)			
Comment: the original sample was too small for a 13C/12C ratio measurement. However, a ratio including both natural and laboratory effects was measured during the 14C detection to derive a Conventional Radiocarbon Age, suitable for applicable calendar calibration.			
Beta - 165502	5410 +/- 50 BP	-25.4 o/oo	5400 +/- 50 BP
SAMPLE : CCFRBS-12			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal BC 4340 to 4060 (Cal BP 6290 to 6010)			
Beta - 165503	190 +/- 50 BP	-25.5 o/oo	180 +/- 50 BP
SAMPLE : CCFRBS-13			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 1640 to 1950 (Cal BP 310 to 0)			
Beta - 165504	210 +/- 50 BP	-26.4 o/oo	190 +/- 50 BP
SAMPLE : CCFRBS-14			
ANALYSIS : AMS-Advance delivery			
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 1640 to 1890 (Cal BP 310 to 60) AND Cal AD 1910 to 1950 (Cal BP 40 to 0)			